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A Study on Restricted Mobility Levels and Trip Characteristics of the Disabled

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The 18th. Japan City Planning Congress,
Reports of Academic Studies Presentation Meeting in 1983.

A Study on Restricted Mobility Levels and Trip Characteristics of the Disabled

Abstract: This report aims to discuss the degree of mobility and characteristics of trip frequency for disabled persons in Machida, Tokyo. We studied 1) the relation between restrictions in mobility and the degree of handicap, 2)trip frequency in relation to the degree of handicap and mobility, 3)the desired frequency of trips,and causes of abandonment of plans for trips.

We conclude that trip frequency is influenced by the severity of the handicap and the degree of mobility. Although the severely disabled generally wish to go out more often than they are able to, they have a tendency to abandon plans for going out. A significant reason is that suitable transportation is unavailable.

1. Introduction

Countermeasures for the mobility of the disabled which were initiated as"the Living Zone Enlargement Movement" in Sendai,Japan, in 1970, have since been improved, but are still insufficient.

In particular, the improvement of access in existing public transportation systems is very poor for such severely handicapped people as wheelchair users. (e.g. Public buses have no lifts, while at railway stations elevators and escalators for the disabled with wheelchairs are rare.) Special transport services for the disabled seem to center on package services, such as transportation services to and from welfare facilities. However, public services, such as buses with lifts, which thus provide individual freedom to the disabled, are generally still yet to be established.

Against this background, Machida City, Tokyo, started services for the disabled by providing slopes between the pavements and roads and by operating a special transportation service.

This report summarizes the results of a survey which was carried out among the disabled who live in Machida City.

(1) Survey methods

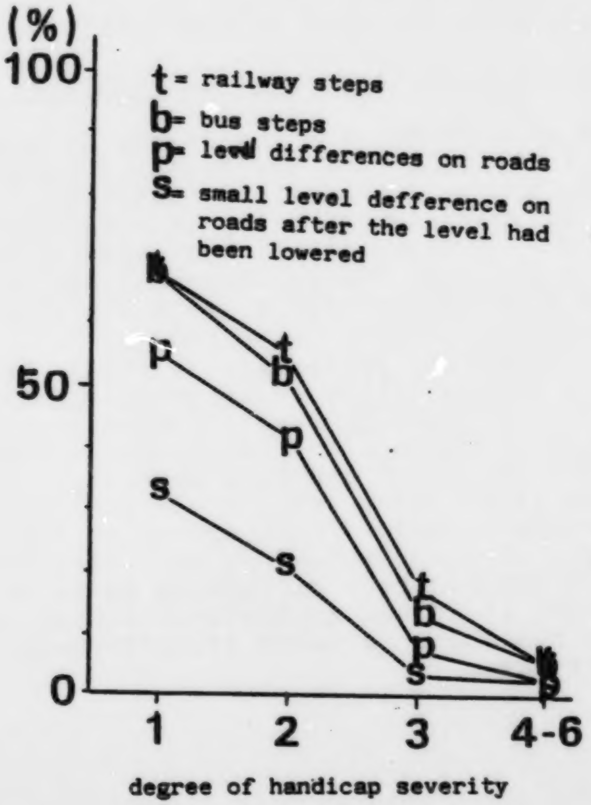
This questionnaire was carried out between December 1982 and January 1983, among physically handicapped people, some of whom were mentally handicapped, who live in Machida City, Tokyo. Because of the difficulty in obtaining lists of the disabled population for a random sampling, the subjects used in this survey were chosen by Disabled associations, who offered subjects for this research. The survey was conducted by visiting each subjects house. 360 questionnaire forms, out of 757 (48% collection rate), were collected, of which, 292(including 9 with mental handicap) were valid. Table 1 classifies subjects according to their type of handicap

Table 1. Subjects according to their type of handicap and degree of handicap severity

level of Impairment	limb and trunk					visually Impaired			other		total		
	lower limb	trunk	total	B	C(%)	A	B	C(%)	A	C	A	B	C(%)
	A	B	C										
1	9	33	42	233	18	21	134	16	11	8	74	503	15
2	11	46	57	418	14	4	77	5	11	8	72	633	11
3	4	15	19	357	5	4	36	11	11	6	34	575	6
4-6	36	11	47	891	5	7	149	5	19	8	73	1,277	6
	60	105	165	1889	9	36	396	9	52	6	253	2,988	8

Note: A;subjects with known type of handicap and degree of handicap severity
B;population of handicapped persons
C;A+Bx100
292 questionaire froms were valid including 9 with mental handicaps and 30 with unknown degree of handicap severity.
Level of impairement; 1-2 is very severe, 3-4 is severe, 5-7 is appreciable

Figure 1. The percentage of subjects who have difficulty in deeling with four mobility restrictions according to the degree of handicap severity



and degree of handicap severity among the total of researched subjects(A) and the total of the disabled population(B). 253 subjects(8% of B) had clearly defined types of handicap and degrees of handicap severity. Table I shows that the greater the severity of handicap, the higher the percentage of subjects in each population.

(2)Aims of the survey and data generalisations

The main aims of this survey are as follows:

1)To establish the relation between the type of handicap and degree of handicap severity with walking ability, which is considered to be the indication of the mobility restriction level(vertical and horizontal mobility),and with the ability to use transportation.
2)To consider the effect of the mobility restriction level on the frequency of trips.
3)To experimentally examine latent trip frequency including desired trip frequency; the percentage of those who gave up going out and of those who asked others to go out for them.

In terms of mobility restriction levels and mobility, given sufficient samples, the results of these studies can be generalised to other cities. However, concerning trip characteristics and latent trip frequency, being dependent on differing transportation service conditions for the disabled in each city, generalisations from these results can not be made. Machida City is an easy place for wheelchair users to move around in, so they are able to go out more often than those who live in other cities.

2.Mobility restriction level and mobility of the disabled

The type of handicap and the degree of handicap severity classified under Article 4 of the Disabled Persons Welfare Act were not determined by the mobility restriction level, but from a medical point of view. Accordingly, in order to understand the relation between the classification of handicaps and mobility restriction, we analyzed the relation between walking ability and the ability to use transportation, with the type of handicap.

(1)Vertical mobility (Figures 1, 2 and 3)

Figure 1 shows the percentage of those who have difficulty in dealing with four mobility restrictions(①.staircases at railway stations ②steps of buses ③level differences on roads ④.small level difference on roads after the level had been lowered) according to the degree of handicap severity. The results suggest that staircases at stations and the steps of buses are the two greatest restriction factors. According to the degree of handicap severity, half of the subjects from the third degree(moderately handicapped) to the 6th have difficulty in negociating these obstacles. Thus, it is not possible to assess the ability to deal with such obstacles in terms of differences in the degree of handicap severity.

Figure 2. The percentages of subjects who have difficulty and those who have little difficulty in ascending and descending staircases at railway stations

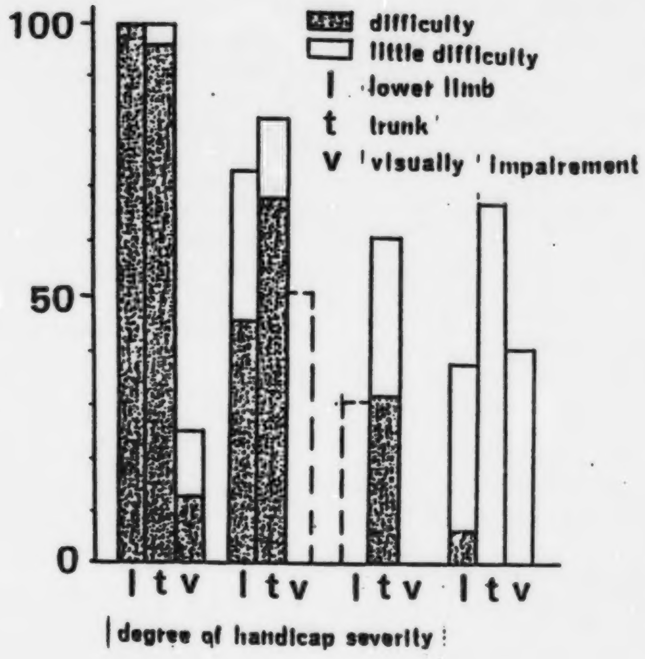


Figure 3. The percentage of subjects who have difficulties negociating staircases at railway stations in relation to use of supportive aids

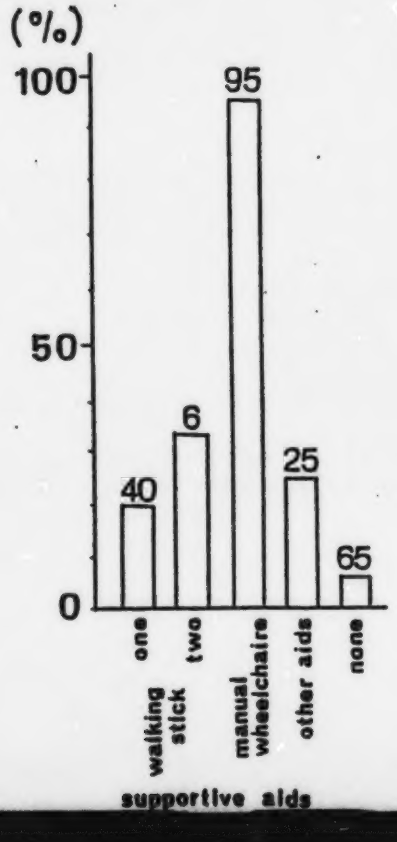


Figure 2 shows both the percentages of subjects who have difficulty and those who have little difficulty in ascending and descending staircases at railway stations (shown in Figure 1) according to the type and degree of handicap severity. Care should be taken with the interpretation of the results of those with visual handicap degrees 2 and 3, and lower limb handicap degree 3, because of the small sample number. According to the types of handicap, the number of trunk handicapped subjects who have difficulty in negociating steps is greater than in the lower limb handicapped subjects with the same degree of severity. This relation was not significantly observed in visually handicapped subjects. Half of the subjects who manage to deal with these obstacles are in the groups of slightly handicapped and visually handicapped (degrees 4,5 and 6).

Figure 3 shows the percentage of subjects who have difficulties negociating staircases at railway stations in relation to the use of supportive aids. The subjects using wheelcairs are almost unable to use staircases, while about 20% of subjects with one walking stick or other supportive aids and only 5% of the subjects without these aids have difficulty using staircases.

(2)Horizontal mobility (Figure 4)

To determine the walking ability of the disabled, the percentage of those with walking difficulties at certain distances in relation to the type of handicap and the degree of handicap severity, is shown in Figure 4. While less than 30% of total subjects are unable to walk more than 1km, 65% have difficulty. Between 70 and 100% of subjects with degree 1 and 2 severities, excluding visually handicapped subjects, have difficulty in walking more than 1km. In lower limb handicapped subjects, disparities in the degree of severity reflect wide differences in walking abilities. However, these differences were not very apparent in trunk handicapped subjects. The results reveal that the disabled are generally poor at middle and long distance walking even though they can actually walk.

(3)Use of transportation (Figure 5 and 6)

Figure 5 shows whether the subjects are able to use various kinds of transport either with or without assistance. With assistance, subjects using the Yamayuri-go service(See note below) or using wheelchairs or travelling on foot have almost no difficulty. However, driving cars, riding on buses, trains or taxis still pose difficulties for them. Without assistance, riding on trains and buses is about 20% more difficult, in each degree of severity, than using other forms of transport. The greater the degree of severity, the greater the difficulty in using transportation without assistance.

The results indicate that severely handicapped people(degrees 1 and 2) become more capable, with assistance, of using transport.

Figure 4. The percentage of subjects with difficulties at the certain distances in relation to the type of handicap and the degree of handicap severity

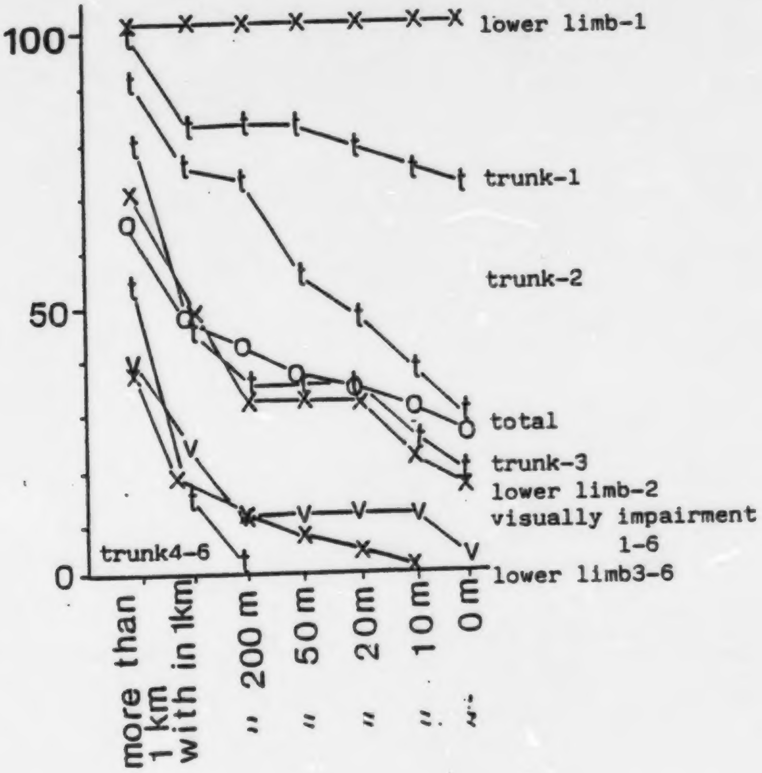


Figure 5. The percentage of subjects who have difficulties in using various kinds of transport either with or without assistance

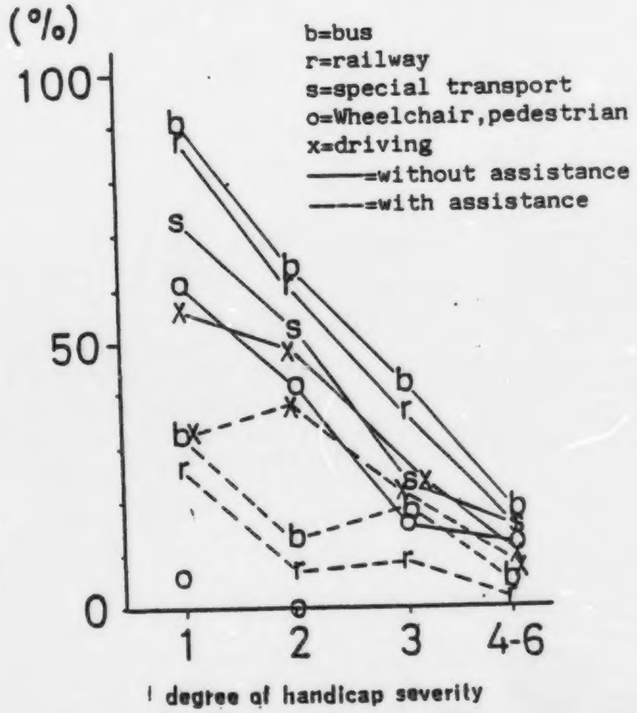


Figure 6 shows the percentage of subjects with wheelchairs who have difficulty in using transport. Over 50% of the subjects have difficulty driving cars and riding bicycles, which are in any event, the hardest. Using buses, trains and taxis becomes progressively easier. Hardly any subjects have difficulty in using the Yamayuri-go service.

Summary of Section 2

1) The degree of handicap severity and the percentage of the disabled who have difficulty in negociating steps are to some extent correlated. That is, the severer the degree of handicap, the greater the difficulty. However, in terms of type of handicap, the number of trunk handicapped subjects having difficulty is greatest, followed by those with limb and visual handicaps.
2) Regarding staircases at railway stations and middle and long distance walking of more than 1km, even slightly handicapped subjects walk with difficulty.
3) With regard to transportation, degree 1 and 2 subjects are governed by whether or not they have assistance.
4) Vertical mobility is determined by whether or not they use wheelchairs. Furthermore, it is difficult for wheelchair users to use cars and public transportation.

3. Mobility restriction level and trip frequency of the disabled

In order to understand what kind of relation the difference the mobility restriction level and the severity of handicap have with the number of trips, a study of the relationship between the vertical and horizontal mobility, use of transportation, degrees of handicap severity, supportive aids and trip frequency was conducted.

The number of trips, including all purposes, were counted and converted into numerical values as shown in Table 2.

Tab.2. Conversion Table for the Number of Trips

Almost everyday =1.00	Once to twice a week =0.21	Less than once in a month =0.02
3 to 4 times a week =0.50	Once to twice a month =0.05	None =0.00

(1) Vertical mobility and trip frequency (Figure 7)

The relation between vertical mobility; such as dealing with staircases at railway stations, steps of buses, level differences on roads, and the number of trips made is shown in Figure 7. In general, the results indicate that the higher the mobility restriction level becomes, the greater the number of trips. The subjects who can climb stairs at stations with ease and those who can manage, but with difficulty, go out about 2.6 and 2.3 times respectively more often than those who can not walk.

Figure 6. The percentage of subjects with wheelchair who have difficulty in using transport

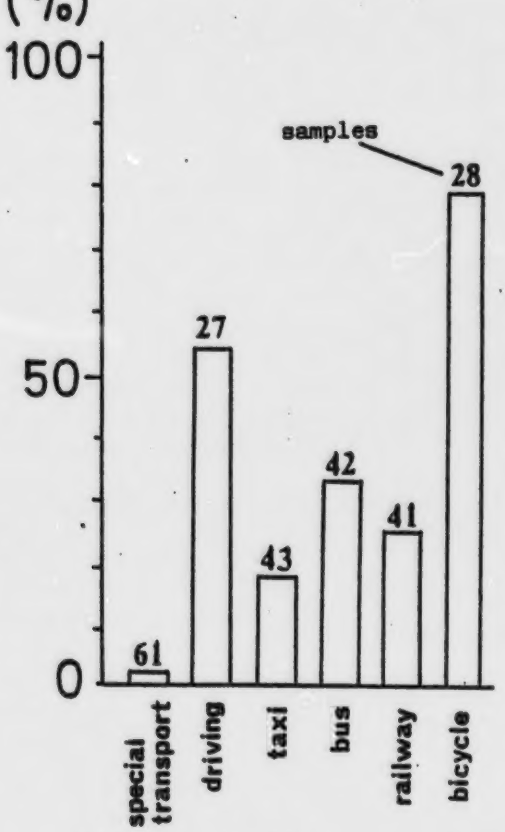
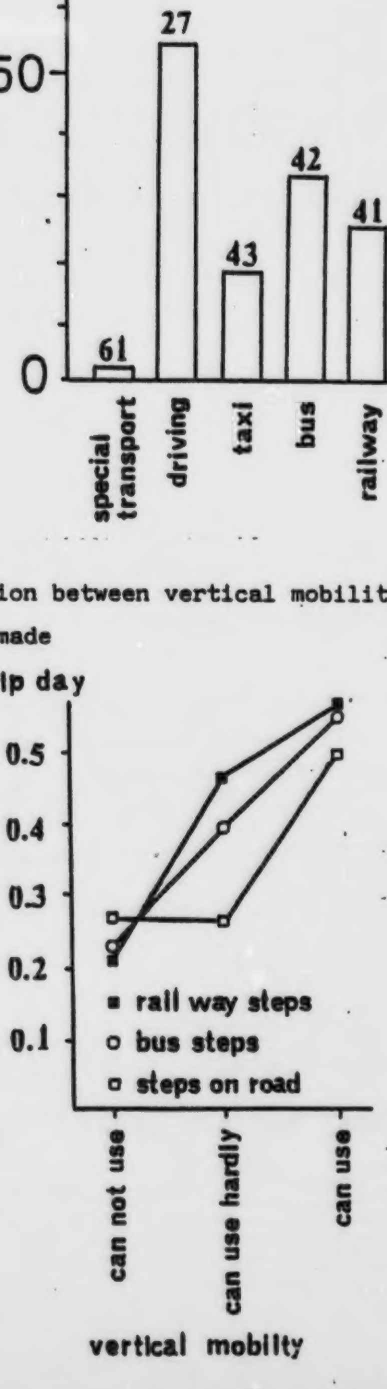


Figure 7. The relation between vertical mobility and the number [illegible] of trips made



(2)Horizontal mobility and trip frequency (Figure 8)

The subjects with a greater walking ability(those who can walk longer distances) go out more often. Those who can walk more than 201m go out about twice as often as those who cannot.

(3)Transportation used and trip frequency (Figure 9)

There is no difference in trip frequency between those who can drive cars and those who cannot. Those who can use transportation by themselves, apart from driving cars, go out between 2 and 5 times more often than those who cannot use transport even with assistance. It seems that those who can use transport without assistance go out quite often,on average 3 to 4 times a week. The trip frequency of those unable to use any kind of transport, even with assistance, is lowest in the Yamayuri-go users(less than 0.1 times per day), because this group includes those who are ineligible to use the Yamayuri-go service and those who go out only very rarely.

(4)Degree of handicap severity and trip frequency (Figure 10)

Those with degrees 4,5 and 6 go out 4 times a week(0.53 times/day). Those with a severe handicap, degree 1, go out twice a week (0.28times/day) which is about half as frequently as less handicapped people(degrees 4 to 6). In fact, the trip frequency correlates to the degree of handicap severity.

(5)Used supportive aids and trip frequency (Table 3)

Those who use supportive aids go out about half the number of times as those who do not. In particular, those who use wheelchairs go out only once to twice a week(0.24 times/day) even though they are able to use the Yamayuri-go service. The trip frequency of those who use wheelchairs, excluding car users,(as full-time workers are included), is extremely low. Those who use other aids or a walking stick go out 2 to 3 times a week, which is 1.5 to 1.6 times more often than wheelchair users.

Tab.3. Trip Frequency According to Supportive Aids

walking stick		manual wheelchair	other aids	none
one	two			
0.379	0.674	0.237	0.365	0.514

Note: As the sample number of 2 stick users is insufficient, little reliability can be attached to the result.

Summary of Section 3

1)Regarding vertical mobility, horizontal mobility and in the ability to use transport, the less the mobility restriction, the greater the trip frequency.

2)The trip frequency of those who cannot walk or who cannot climb up

Figure 8. The number of trips made according to mobility restriction level of horizontal mobility

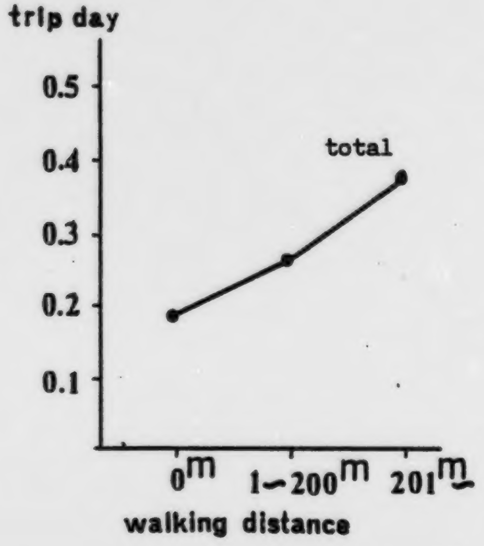


Figure 9 The number of trips made by using various kind of transportation either with or without assistance

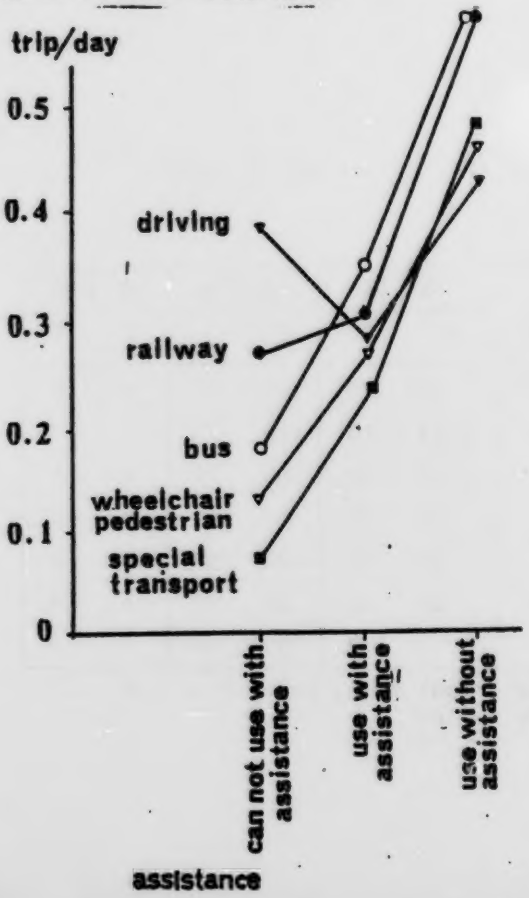


Figure 10. The number of trip made according to degree of handicap severity

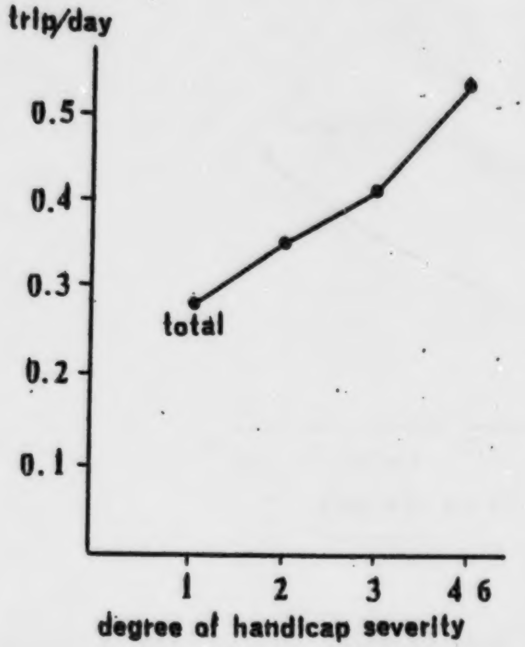


Table 4. The number of desired and actual trip

	A < B		A = B		A > B	
trip purpose	N	%	N	%	N	%
shopping	39	25	109	71	6	4
medical	23	16	115	79	8	4
visitting	30	22	100	72	9	6
leisure	40	36	68	61	4	3
walking	33	23	97	68	12	8
welfare	28	24	86	72	5	4
commuting	3	3	89	94	3	3

cf) A= actual trip, B=desired trip
N= number

staircases at railway stations, is very low.
3)The main factor controlling trip frequency is whether or not it is possible for them to use transport by themselves.
4)The relation between the degree of handicap severity, which is classified from a medical point of view, and trip frequency, shows that the lighter the handicap,the higher the trip frequency.
5)Trip frequency is largely dependent on whether or not supportive aids are necessary. The trip frequency of wheelchair users is low,while those who do not use supportive aids go out more often.

4.Number of latent trips

The above study showed that the more severe the handicap is, and the harder it is to have access to transport, the less frequently the disabled go out. This study was conducted to analyze the following three points for the purpose of determining the number of latent trips;

i)the number of desired trips and actual trip frequency
ii)the relation between the degree of handicap severity and the mobility restriction level in those who gave up going out, and reasons for not doing so.
iii)the relation between the number of those who asked somebody to go out for them and the degree of their handicap severity.

(1)The number of desired trips and actual trips (Table 4, Figure 11)

Table 4 shows the number and the rate of subjects classified in three groups according to the purpose of the trips;
①.those who have made fewer actual trips than desired trips
②.those who have made as many actual trips as desired drips
③.those who have made more actual trips than desired trips

The results indicate that;
.60% to 70% of those who made as many actual as desired trips for any purpose, excluding commuting and attending school, are satisfied maintaining the present situation.
.20% to 30% of those who have made fewer actual trips than the number of desired trips wish to go out more often.
There are very few who wish to go out less often.

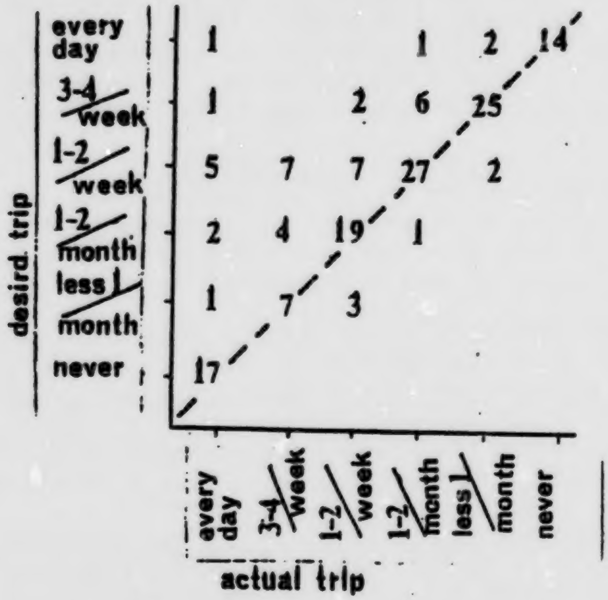
Figure 11 shows the number of desired and actual trips according to trip frequency for the purpose of shopping and recreation. For shopping, all of those who hardly go out at all and those who go out 3 to 4 times a week, wish to go out more often. Furthermore, in terms of recreation, those who have a low actual trip frequency(no trips or less than once a month) wish very strongly to go out. The group wishing to maintain the present situation, often go shopping while those who hardly venture out wish to go out for recreation.

(2)Those who gave up going out and their reasons (Figure 12,Table 5)

137 subjects out of 262 gave up going out(52%). Figure 12 breaks down the 137 subjects into the type of handicap and the degree of handicap severity. The greater the handicap, the more subjects

Figure 11. The number of desired and actual trip

—shopping—



-leisure-

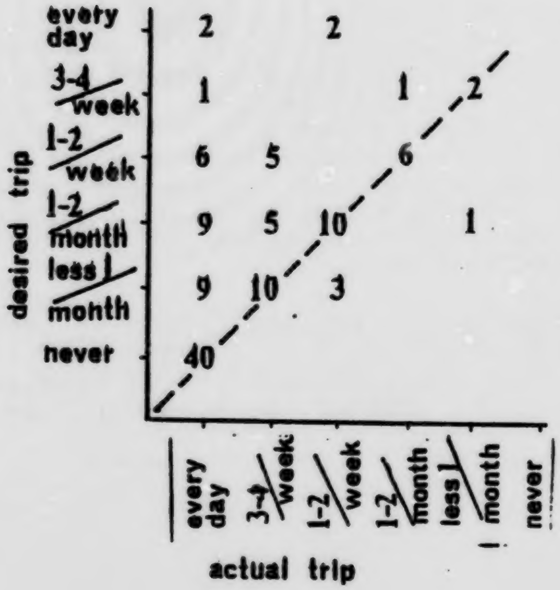


Table 5. The reason for giving up going out

reason	numbers	%
has not any transport	18	18
has not any assistance	18	18
difficulty to walk	5	5
barrier of road and bulding	5	5
inexperianced for his handicap	2	2
without parking	2	2
prejudice	6	6
tired and be in bad health	20	20
bad weather and no money	5	5
others	19	19
total	100	100

gave up going out apart from the visually handicapped. The reasons are given in Table 5. About half of the subjects listed restriction on transport such as, its non-availability, lack of assistance, difficulty in walking, difference in road levels, problems at entrances and difficulties over parking. The actual handicap itself is directly a reason for less than 30% of subjects, who mention they dislike social discrimination, are in poor physical condition, or find going out tiring. In short, about 80% of the subjects cited their handicap as a direct or indirect reason for not going out.

(3)Those who asked somebody to go out for them (Figure 13)

65% (175 of the total subjects) had asked somebody to run errands for them. Figure 13 shows the percentage of subjects who asked somebody to go out for them against the type of handicap and degree of handicap severity.

Little relation can be discerned between the total subjects and the degree of severity apart from in degree 1 group. For subjects with severe trunk handicaps the more severe the handicap the greater the incidence of asking somebody to go out for them. However, visually handicapped subjects have almost the same percentage, in spite of differences in degree of handicap severity.

Summary of Section 4

1)Concerning trip trequency, most of the subjects desire to go out as frequently or more often than they do now. Those who rarely go out wish to go out for recreational purposes.
2)Those who are severely handicapped gave up going out more often, about 80% of whom gave their handicap as the reason. Those with a lower mobility restriction level gave up going out less often.
3)There is hardly any relation between asking somebody else to go out and the severity of the handicap.
4)There is a relation in the number of latent trips between the number of desired trips and the number of trips given up. However, no relation was found between latent trips and the number asking others to go out for them.

5. Conclusion

The problems of this study and recommendations for further research are as follows;

Firstly, this study did not carry out any research on dexterity(e.g. ability to grip), speed of motion(e.g. ability to board transportation quickly), physical limits(e.g. length of time being able to keep standing, or being able to walk around in a crowd) or individual property(possession of drivers' licence or cars). However, this study did manage to reveal a relation between mobility restriction levels, walking abilities and whether transportation could be used or not.

Secondly, as the number of the samples were small and there was a limit on , a detailed analysis could not be conducted.

Figure 12. The percentage of those who gave up going out

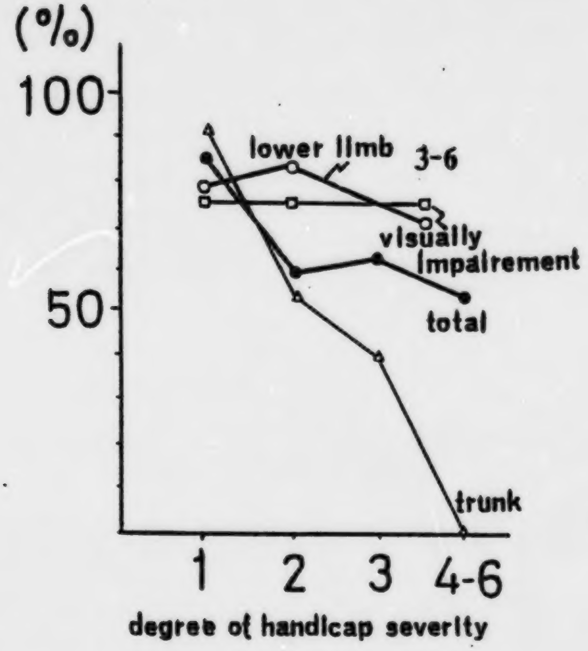
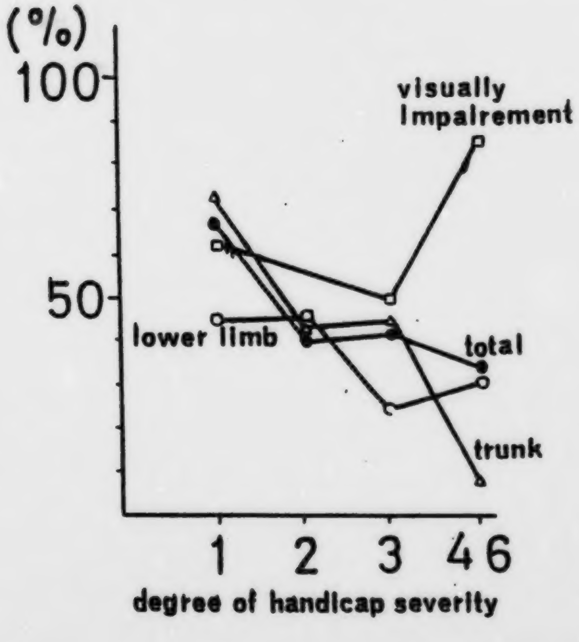


Figure 13. The percentage of those who asked somebody to go out for them according to type of handicap and degree of handicap severity



Thirdly, although the study was experimentally carried out on latent trips through questions, such as the number of desired and given up trips and the number of trips which others were asked to perform for them, the content of the questionnaire could have been expanded.

Note: Yamayuri-go is a minibus with a lift, in which the disabled can ride in their wheelchairs or on stretchers. Machida City started the service, in 1972, as a convenient means of transportation for the disabled with walking difficulties living in Machida. To use the service, the users have to be eligible and to make an appointment by the 20th of the previous month. The users can use the service free of charge to make trips within office hours.

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Table 1. Subjects according to their type of handicap and degree of handicap severity

Note: A; subjects with known type of handicap and degree of handicap severity
B; population
C; A/Bx100
292 questionnaire forms were valid including 9 with mental handicaps and 30 with unknown degree of handicap severity.

Table 4. The number of desired and actual trips

Table 5. The reasons for giving up going out

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Figure 11. The number of desired and actual trips

Figure 12. The percentage of those who gave up going out

Figure 13. The percentage of those who asked somebody to go out for them according to type of handicap and degree of handicap severity

Underlying Factors in the Development of Demand Responsive Transport in Britain

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1. Introduction

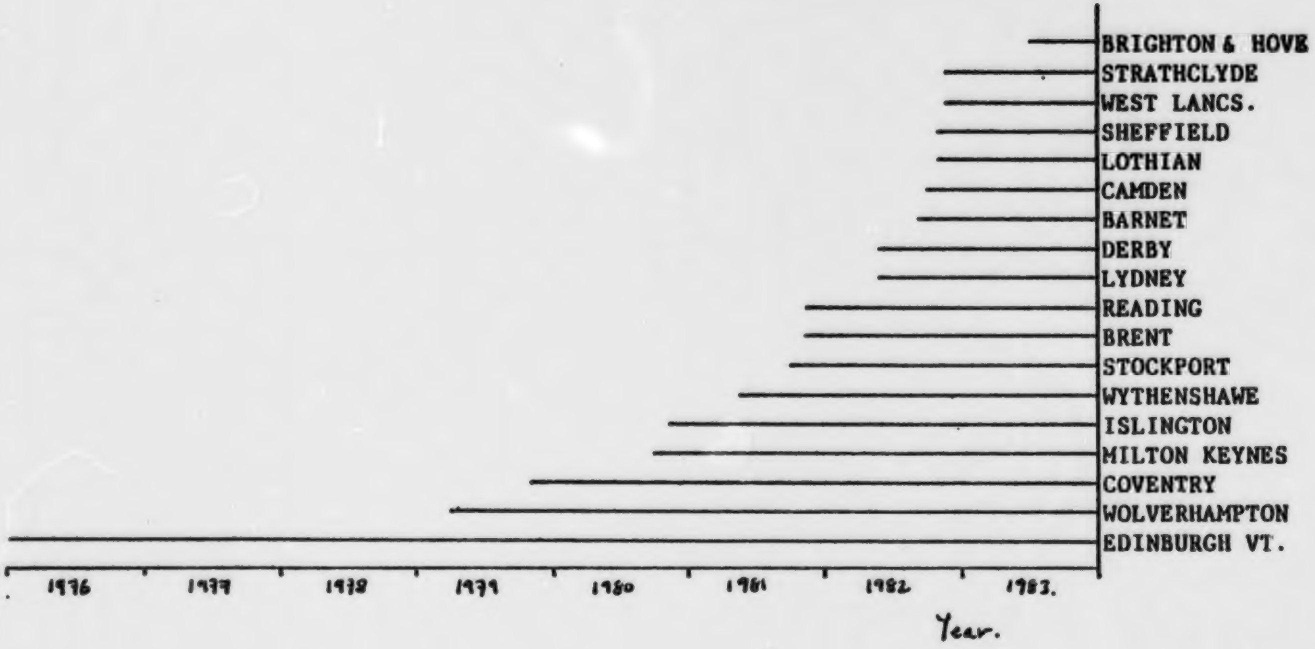
Improvements to mobility opportunities and transport for elderly and disabled people in the U.K. have generally concentrated on income support (i.e. the mobility allowance) for the most severely disabled, concessionary bus fares for the elderly and the provision of transport services for medical care, day care and social rehabilitation for both groups (see Garden 1979). The voluntary sector has specialised in transport for organised activities and, to a much smaller extent, for personal travel needs. (Bailey 1979).

Non-car-owning, low-income elderly and disabled people, not receiving mobility allowance and unable to use public transport, have generally been left with no means of travel for personal journeys. Mobility allowance beneficiaries who are too disabled to travel by car or taxi, have also found that specialist services for personal travel simply do not exist, even if they are prepared to pay for them. Over the last four years there has been a sudden and appreciable upsurge in the provision of transport to fill this important gap.

Exact figures on the nature and growth of transport schemes are difficult to come by as there is no all embracing directory, and certainly no statistical evidence at national level. (A National Advisory Unit has been set up to monitor progress and develop expertise, so more comprehensive information will probably become available in due course). Moreover there is no standard pattern of operation and organisational structure, and this leads to difficulties in classifying schemes. Various information sources were therefore used to compile a list of seventeen demand responsive services which could be studied in more detail. The seventeen were selected to provide a good cross section of service types and organisations, but they cannot be taken as necessarily representative of all schemes in existence.

Figure 1 Dial-a-Ride for Disabled People: Some Schemes

Currently Operating



A tape recorded interview was conducted with each organiser and any available data was collected. The full results of this survey are recorded elsewhere (Bailey and Appleby 1983). They also form the basis of this paper, but further more extensive and detailed surveys are being carried out as part of a larger study.

Figure 1 shows the period over which each of seventeen schemes have been operating (it also includes the Reading scheme which was part of a separate study, Heraty 1984). Note the recent growth in services, particularly after 1981.

The aim of this paper is to explain some of the factors underlying these recent trends. Why and how has the growth come about?

The paper is divided into sections as follow:-

(i) the role of the voluntary sector,

(ii) the availability of funds,

(iii) legislative changes,

(iv) discussion and assessment,

(v) summary and conclusions

2. The role of the voluntary sector

The term 'voluntary sector' is not necessarily synonymous with 'volunteers'. A voluntary organisation is essentially a non-profit organisation which determines its own policies. This often means that it employs professional paid staff in addition to volunteers. Moreover, the scope of the voluntary sector comprises many different groups, for example: interest and pressure groups at national level; direct providers of services (e.g. transport), social and welfare groups at local level; and self-help community groups. As one would expect therefore, the issue of improving transport and mobility for disabled people has been taken up in different ways by different groups.

National pressure groups in Britain certainly contributed to the emergence of the Mobility Allowance, disabled persons car scheme (Motability), parking concessions and other developments, but have probably not been as vociferous as their US counterparts on issues of public transport. Developments at local level have been much more significant here.

During the 1970s there was a substantial growth in the number of social and community groups concerned with elderly and disabled people (Hatch 1980). Their role in providing social clubs, outings and meals at centres, for example, inevitably lead them into the area of transport provision

(Bailey 1979). Many groups began to organise volunteer drivers, using their own cars to bring people to meetings. Others purchased their own mini-buses. A whole new movement called community transport began to grow up around these services. The national organisation Community Transport was set up specifically to coordinate these groups and provide transport services for such activities. It currently operates local schemes in seven cities.

In rural areas a different form of community transport also began to grow. This was primarily to provide a substitute for declining public transport services. Again volunteer car drivers, or minibuses driven by volunteers, were used, in some cases providing regular scheduled services. As Bell (1983) has stated, the community transport concept itself is therefore somehwat confusing. However, it was mainly the urban-based movement which took on the role of campaigning for better transport for disabled people. A number of studies carried out during the late 1970s (e.g. Norman 1977, Bailey 1979 and Spastics Society 1979) identified the gaps in the provision for personal travel needs, which the community transport movement seized on, as both the campaigner and provider of services.

The essential element of the new approach to travel needs being adopted by the community transport movement was its liberating potential: i.e. the basic philosophy of individual freedom of choice with the minimum of constraints. This contrasts strongly with previous practice in the provision of voluntary transport which sought to meet only 'urgent' and 'pressing' needs and to provide transport only after a careful vetting of the case.

By 1980 a few demand responsive door-to-door services were operating, namely in Edinburgh, Manchester, Milton Keynes, Coventry and Islington (London). They generally used one or two small vehicles capable of carrying a passenger in a wheelchair and one other, and operated like a private hire car. Interestingly, the two latter schemes were operated directly by local municipal authorities. In the Coventry case only an off-peak service was provided. This scheme in fact used two 13-24 seat buses with the important secondary objective of utilizing such vehicles at a time when they would otherwise be standing idle.

Most of these schemes, and many subsequent ones, have identified with the name 'dial-a-ride'. This concept originated in the early 1970s (Oxley 1970) as a new type of demand responsive public transport service using small, radio controlled vehicles. At the time it was operated by bus companies as a means of serving sparsely populated areas with low levels of public transport demand, providing services in more densely populated areas at off-peak times and offering better quality public transport which might attract car users. Dial-a-ride schemes of the 1970s could not be justified on economic grounds and failed because they did not provide good value for money at a time of financial cut-backs. Their potential as a form of specialist transport for elderly and disabled people was not therefore exploited at the time (see Bailey 1984).

Whilst it is probably true to say that the schemes of the early 1980s grew out of the dial-a-ride idea, they operate much more like a taxi (i.e. providing exclusive ride service based on a charge for the vehicle) rather than a bus (i.e. allowing shared rides and charging separate fares). Primarily this reflects the philosophy of many schemes to provide a high quality personal service with the minimum of restrictions (i.e. no zoning or routeing). The ability for voluntary and social organisations to charge separate fares outside the public transport legislation was granted in 1977 (see later). They did not therefore have to face the same controls as the earlier dial-a-rides. The main reason why services began to develop when they did was the availability of funds. Much of the growth in funds was from government sources, as we shall see in the next section.

A secondary, but none the less important reason for the recent growth, was the International Year of Disabled People (IYDP) in 1981. This provided a new focus of interest, nationally and locally, on the needs of disabled people. Many local groups wanted to do something different that would be helpful and useful and at the same time identifiable as an IYDP initiative. Improving transport was an obvious candidate.

3. The availability of funds

Up until the late 1970s at least, the primary source of funds for voluntary organisations has been shown by a number of surveys (eg. Johnson 1978, Bailey 1979) to be donations and fund raising schemes. The latter include collections, raffles and other special events. There is also evidence of grant aid support from local authoriies, but the development of the organisation has often depended heavily on the skills and enthusiasm of the volunteers in a regime of very limited resources.

An essential element of volunteer input is its part time nature. Volunteers cannot be expected to work the same hours as paid staff. Therefore the all-day-seven-days-a-week service envisaged by the new dial-a-ride schemes posed a significant dilemma for traditional methods of staffing. Such a service could only be provided on a voluntary basis if the number of staff is increased dramatically. But this was likely to result in severe management as well as recruitment problems. There was, therefore, little alternative but to employ at least some paid staff.

This need for paid staff immediately posed a severe financial constraint on the development of services. The schemes which had developed during the late 1970s represented something of a breakthrough in funding.

The two main sources of funds were: (i) the government's Urban Programme, (ii) special initiatives from local municipal authorities.

Although set up in 1969 to provide funds for urban areas suffering from economic, environmental and social problems, the Urban Programme had not been a major source of funds for voluntary organisations providing transport until the late 1970s. Grants to voluntary organisations under the Urban Programme totalled about £43m in 1982/3. They have been growing at an annual average rate of about 45 per cent over the 3 years prior to this (NCVO 1983).

Grants are awarded on the basis of a 75 per cent share from central government and 25 per cent from the local authority. There is thus a two-stage vetting process except for local authorities themselves who are also eligible for grants. The two local authority schemes in Coventry and Islington (London) are in fact funded on this basis. Grants are relatively long-term, up to five years and can include all revenue and capital items.

The New Town Development Corporation and local authority at Milton Keynes were the main sources of funds for the project which developed there (see Lightfoot, 1981). This was more the exception than the rule. However, recent involvement by the Greater London Council has been very significant. In a major initiative in 1982 they set aside £600,000 to finance experimental transport schemes for disabled people over the subsequent 3 years. By July 1984 they are committed to funding 11 dial-a-ride schemes and to implementing a user-side subsidy scheme for the whole of Greater London at a cost of £1.1m. London Boroughs such as Camden and Islington are also getting involved in funding as are the metropolitan counties in the rest of the country.

Apart from the growth in sources of funds which already existed in the early 1970s, other new and important sources have emerged. Primarily these relate to the rising tide of unemployment and are intended to finance job creating schemes for school leavers and the longer term unemployed. Such funds are available from the Manpower Services Commission (MSC) of the Department of Employment.

The main programmes are:

(i) the Youth Training Scheme. This was originally introduced as the Youth Opportunities Scheme in 1978 and aimed at providing work experience and training for unemployed school leavers for up to a year. During the early 1980s, about 500,000 places were being provided annually on this scheme.

(ii) The Community Programme (CP). This was introduced in 1982 with the aim of providing 130,000 places for people aged 18 and over who have been unemployed for at least 12 of the previous 15 months. It similarly offers employment for a maximum of 12 months. The introduction of the CP

FIGURE 2
MAIN SOURCE OF FUNDS FOR SCHEMES STUDIED

	Urban Programme	MSC	Local Authority	Govt. Funding for Volunteers	Private sources donation
BARNET				*	*
BRENT	*				
BRIGHTON		*	*		*
CAMDEN			*		
COVENTRY	*		*		
DERBY	*		*		
EDINBURGH Vol.Trans.			*		
ISLINGTON	*		*		
LOTHIAN		*			*
LYDNEY					*
MILTON KEYNES		*	*		
READING	*		*		
SHEFFIELD	*	*			
STOCKPORT		*	*		
STRATHCLYDE	*				
WEST LANCS		*			
WOLVERHAMPTON	*				

represented a major effort to provide 4 times the number of places compared to previous MSC schemes which had operated from 1978. However this was mainly to be achieved by a shift from full time to part time staff. The MSC agree to pay a maximum of £60 per week per place. The exact hourly rate for the job was to be agreed locally. Thus a full time worker (say 40 hours per week) would have received only £1.50 per hour. Current rates for drivers are probably about £2 per hour.

Apart from the restrictions on employed staff, the big disadvantage for dial-a-ride operators funded by the MSC is the limitation to one year's employment. This is obviously detrimental to building up a good teamwork approach, commitment to the service, and a relationship of trust and reliability between drivers and passengers. The one year rule applies not only to staff but to the overall funding of the scheme as well. Although a scheme grant can be extended, as many have been, they must employ new staff who meet the MSC conditions.

The growth in unemployment has also lead to the provision of funds to support volunteers (ie. meeting the costs of overheads. materials, etc.). There are two main sources:

(i) The Department of Health and Social Security (DHSS), Opportunities for Volunteering fund.

(ii) The Manpower Services Commission, Voluntary Projects Programme.

The DHSS scheme is limited to work in the health and social services fields. The MSC scheme, has a wider brief, but is limited to unemployed people and provides only one year's (voluntary) work. Neither scheme would of course provide the primary source of funds for dial-a-ride, but they could and have provided useful supplementary funding. Many schemes do in fact utilize a variety of different funding sources as Figure 2 shows.

4. Legislative changes

Recent legislative changes have influenced the growth of dial-a-ride in two related respects: the emergence of a legal basis for charging separate fares, and a relaxation of the quantity and quality control conditions relating to service characteristics, vehicles and staff. Prior to 1977 there was no legal basis on which individuals could be charged separate fares for a transport service, other than the Public Service Vehicle (PSV) regulations which governed the operation of buses and coaches. After much pressure from voluntary organisations (eg. NCSS 1977) a Private Members Bill went through Parliament becoming the Minibus Act 1977. It enables organisations cocerned with education, religion, social welfare or other activities for the benefit of the community to charge separate fares.

FIGURE 3
AREA COVERAGE OF SELECTED U.K. and U.S.A. SCHEMES

	No. of Vehicles	Vehicles/ 100 sq. km.	Trips/vehicles/ month.	Average cost per trip ($)
U.S.A. Schemes				
ROCHESTER	8	1.46	625	7.64
NAUGATUCK	15	16.64	633	8.40
PORTLAND	11	7.35	670	7.31
WESTPORT	5	14.12	340	-
NEW YORK CITY (EASYRIDE)	10	310.56	423	10.83
PROVISO TOWNSHIP	2	4.29	555	5.88
WILL COUNTY	6	0.44	423	5.50
			---	----
			MEAN 524	MEAN 7.59
U.K. schemes			(1)	(£)
CAMDEN	6	27.62	-	-
MILTON KEYNES	1	0.32	272	10.78
EDINBURGH	2	0.75	88	9.44
LOTHIAN	6	0.34	66	16.16
STOCKPORT	2	0.16	164	3.26
WEST LANCS.	1	3.06	236(2)	6.99
BARNET	1	1.12	23	7.53
COVENTRY	2	2.07	237	5.06
ISLINGTON	2	13.44	300	4.70
DERBY	2	2.56	217	5.19
WOLVERHAMPTON	1	1.45	150	4.32
			---	----
			MEAN 175	MEAN 7.34

Sources: US: Spear et. al. (1981), Middendorf et. al. (1983)
UK: new surveys as part of the study

Notes: (1) Changes in vehicle fleet size over the period surveyed are taken into account. Passenger figures exclude escorts.
(2) Passenger figures include escorts.

provided they did not carry the public at large, but rather their own members or clients.

Many of the strict conditions on vehicle safety, e.g. vehicle maintenance and emergency exits, still apply, but conditions of 'comfort', e.g. seat spacing and headroom, have been relaxed. A system of permits was set up under the Act. This has subsequently been consolidated into the Public Passenger Vehicles Act 1981.

A number of voluntary organisations, local authorities and other bodies were designated in 1980 as being allowed to issue permits in addition to the main public transport licencing body, the Traffic Commissioners. Once issued, permits stay in force unless revoked. However, each new vehicle requires a separate permit. The number of permits issued is currently running at about 2000 per year (Department of Transport 1983). They include all passenger transport services provided for social and welfare purposes, of which dial-a-ride comprises an unknown, but probably small part. The legislation on permits, applies to vehicles with 8 or more passenger seats. Subsequent legislation allowing separate fares to be charged in smaller vehicles was incorporated in the Transport Act 1978.

This allows payments for car sharing as a contribution to running costs. There are no restrictions on journey purposes or groups of people involved, but services operating commercially are excluded and there must be no element of contribution in addition to running costs. Commercial taxi and hire car schemes can be organised by local authorities and are then allowed to advertise.

5. Discussion and assessment

The important question to be addressed in this section, is the combined effect of the factors discussed on the nature of the transport services which have emerged. UK schemes, in general, are smaller (in terms of numbers of vehicles) than their US counterparts and operate over a larger surface area (see figure 3). Many organisers have argued that demand has rapidly outstripped the available resourses. There is some evidence of a rapid growth in demand for new services (e.g. West Lancashire and Stockport) and even the older schemes (such as Islington and Edinburgh) are still experiencing some growth (see figure 4). However the level of trips/vehicle/month for UK schemes is still very much below that for comparable US schemes (see figure 3). This suggests that, in general, there is scope for further expansion. In fact the objective of providing a service with the minimum of restrictions on users has lead many voluntary organisations into a situation where their available capacity is being very poorly utilised. Some schemes allow individuals to reserve the vehicle for long journeys and/or to await a return. Given the equally important objective to provide a widely available service, current practice to overcome this problem has been to restrict the number of advance bookings held by an individual at any one time and the maximum period in which advance bookings can be made. The consequences of this policy can be profound, for example:-

(i) Regular bookings for work, education and shopping trips cannot be accepted, leaving a major gap in service provision.

(ii) Each journey requires considerable planning and booking well in advance. Although prepared to accept last minute bookings, few schemes appear to be in a position to do so in practice. Indeed the difficulties of making a booking (trying to get through on the telephone and then obtain the time you want) have been a major problem highlighted in recent surveys (Bowlby, Kirby and Swann 1984, Bailey and Appleby 1983).

(iii) Travelling independently represents something completely new for many potential users. Such a major change in lifestyle often requires considerable forethought and psychological preparation. Many schemes have emphasised in their publicity, the need to raise the travel expectations of users. The confidence of the user can therefore rapidly diminish again if his travel expectations are immediately dashed as a result of booking difficulties.

Possible alternative courses of action which have generally not been followed are:-

(i) Identify the main corridors of travel and attempt to cater for these by a more structured service operating in specific areas at specific times of day. Limited services of this type do now in fact operate. It may also be possible to allow hail and stop facilities. if vehicle capacity allows, to avoid the need for booking at all. In theory this would reduce the availability of service to any one area but would probably make it easier to book in practice. Moreover, it would still be possible to provide completely unscructured many-to many services at off-peak times.

(ii) Increase the level of resources available to each scheme. There are obvious financial barriers to doing this.

(iii) Adopt a revised charging structure to limit demand to available capacity, discriminating between particular groups of users if so desired. Charges and charging structure do not appear to have been used very much as a means of influencing demand. In many schemes charges have been set more with a view to achieving equity between users; some involving quite complex elements of mileage rates, fixed charges, time based charges and zonal fares. Even though fares appear to differ markedly between schemes (Bailey and Appleby 1983) the level of subsidy is generally in excess of 75 per cent and more commonly

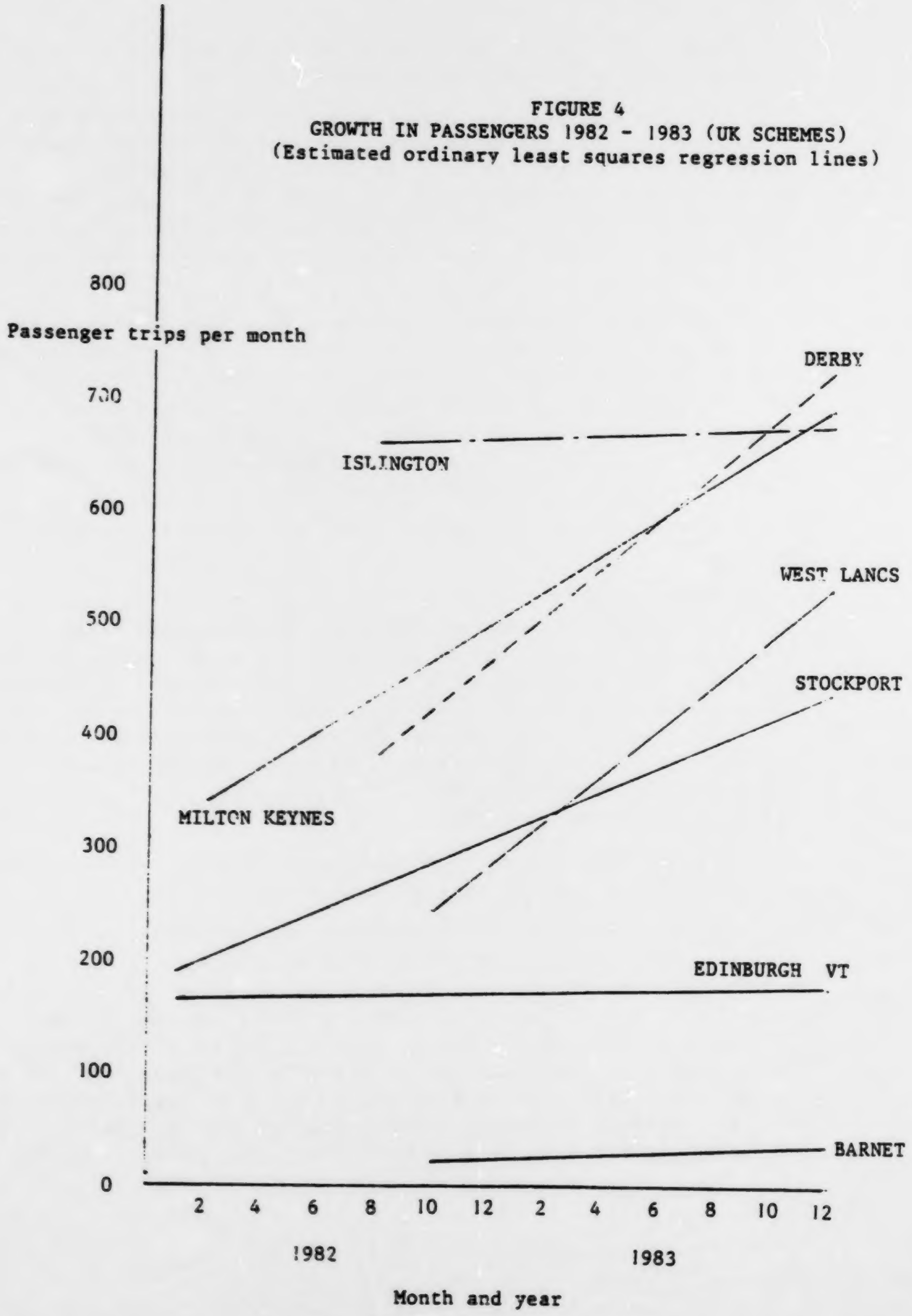


FIGURE 4
GROWTH IN PASSENGERS 1982 - 1983 (UK SCHEMES)
(Estimated ordinary least squares regression lines)

around 90 per cent.

The extent to which services are meeting needs in a cost effective manner has been somewhat obscured by the social policy and employment creating objectives of the bodies providing funds. There is no mechanism for evaluating value for money as a transport service per se, nor any specific policy on meeting needs. Academic or not, the needs question is one which we wil be addressing in our subsequent research. But cost effectiveness, at least in terms of a comparison with US schemes, can be broadly assessed from figure 3. The average cost figures are given in dollars for the US and pounds for the UK, so readers can make their own assumptions about exchange rates. The mean for the UK schemes appears to be higher than the equivalent figure for the US, with a somewhat greater dispersion in the UK case. Much more evidence is required on this, particularly to allow a comparison between special transport, user side subsidies and accessible public transport.

Given the growth in the numbers of paid staff, a final important issue to be considered is that of the role of paid staff in a voluntary organisation and their relationship to volunteers. This is not a new issue, but has grown in importance with the increased emphasis on paid staff employed by voluntary organisations. In essence the organisational and managerial requirements within a voluntary organisation are likely to be similar to those required in the public and private sectors, but its underlying philosophy of caring and democratic control can result in staff management difficulties. As two organisers have put it:

> *"It is expected that staff roles will overlap and that decision making will be shared. This structure can make a teamwork approach difficult as the co-ordinator is at one time both directing and sharing decision making."*
>
> *"Everyone's post is not so well defined as in the commercial sector and the hierarchies aren't defined."*

Such difficulties are exacerbated in voluntary organisations employing both paid staff and volunteers. The problems here relate similarly to role definitions and positions in the hierarchy. For example, the volunteer may not consider himself part of the same hierarchy as the paid staff and, therefore, not subject to the same management control, constraints on working hours and individual responsibility for the work he undertakes.

6. Summary and Conclusions

The voluntary sector has been paramount in providing the enthusiasm and motivation for the recent developments in schemes. However, the sudden take off in the 1980s reflects the greatly increased availability of funds, the much freer legal regime and the special interest generated by the International Year of Disabled People (1981).

For many schemes funding still remains somewhat insecure. Funds appear to be allocated according to criteria outside the control, and often even the influence, of scheme organisers. These criteria may change at short notice in response to changes in the broader objectives of social policy. Schemes funded by the Manpower Services Commission have to face, in addition, frequent staff changes which have a severe debilitating effect on the service. This has repercussions on the staff/passenger relationship and on the quality of service offered as well as the general organisational stability of the scheme.

Many schemes now face problems related to booking difficulties, which appear to be mainly a consequence of their failure to reconcile two conflicting objectives, namely: maximise both the number of users and the number of journeys per user. There is clearly a need for a much more careful consideration by organisers, of the alternative operational characteristics and constraints open to them and the effects of these on users.

The management and organisation of some schemes has become more complex because of the increasing number of paid staff within a voluntary organisation, and even more so where these staff work alongside volunteers. It is early days yet to see how significant this is likely to be, but the problems are likely to increase with the average size of schemes. At the moment most schemes are fairly small. Their financial horizons are also very short.

The idea of dial-a-ride as the key to liberation and freedom of movement for disabled people, which seems to have emerged from the 1970s, has overshadowed to some extent the need to consider the practical issues involved. The development of dial-a-ride has also taken place well in advance of a consideration of the wider issues such as cost effectiveness in the light of alternatives and an appropriate basis for funding. Taxis accessible to wheelchair users, user-side subsidies and improved access to public transport are all beginning to develop alongside dial-a-ride. Undoubtedly these are issues which will have to be faced in the future. However it is perhaps entirely appropriate that the voluntary sector should be concerned with introducing services where nothing at all existed before and articulating, the now very evident demands of disabled people, for some form of special transport.

Acknowledgement

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SPACIAL DESIGN TECHNIQUE

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SPACIAL DESIGN TECHNIQUE

1. Introduction

The spacial design technique is a method of determining the three dimensional space needs of disabled persons when the size and functional characteristics of mobility aids are a significant factor in design.

This paper describes spacial design for a four wheeled chair and user and in particular a manually operated adult size wheel chair with a pair of castered wheels at the front and a pair of large wheels with propelling rings at the rear.

This spacial design technique applies equally to a consideration of other types of mobility aid either for the special needs of individual users or of groups of users.

A consideration of the basic design problems is followed by the research aims and problem solutions. A description of the developed technique is followed by examples of how this design method has been used to solve both simple and complex space design problems that could not be solved using traditional design methods.

2. The Design Problems

It has been found that works produced to existing codes and standard practices do not always meet the needs of the disabled persons for whom the facilities are intended.

It has also been found that codes and practices often do not cover situations found in practice particulars when modifying existing buildings or where economy in costs and use of space is of major importance or where the needs of particular individuals or selected groups of individuals must be met.

Design recommendations by ISO, USA, UK, Australia and other countries are at times in conflict and generally lack information on the size and type of user, mobility aid and the access manoeuvres on which the recommendations are based.

Available codes and practices on space requirements generally state the minimum or maximum allowed in design without information onthe relationships between variables which data would permit flexibility in design and could result in more economic and useful facilities for disabled persons.

It appears clear that past training and experience in architecture, engineering and related professions and the use of available codes and practices is not sufficient to ensure good design in the field of access for disabled persons.

It seems essential for designers to have also a good understanding of disabled people, their abilities, the aids they use, the manoeuvres they need to perform, the range of sizes and the degrees of skill in mobility involved.

There seems also a need for methods of design that take account of the many site variables involved and that yield good designs of modified or new facilities that are safe and useable by the persons for whom intended.

It is to these ends that research into spacial design was directed.

3. Research Aims

The basic aims of the research were as follows

To provide:

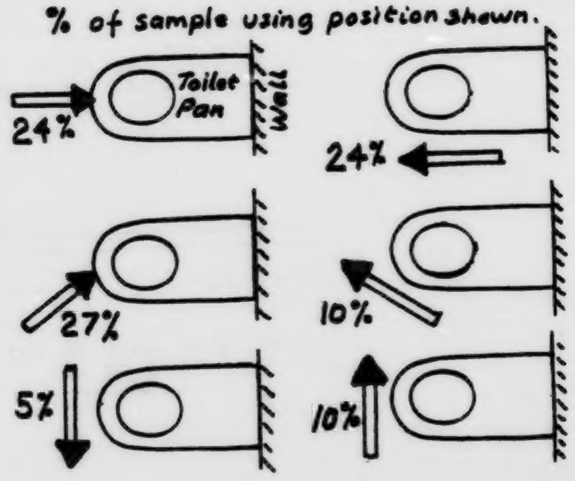
1. A desk method of determining design layouts and spacial dimensions.
2. A method of making sound spacial decisions based on real people and equipment but that does not require subsequant field testing of each situation studied to establish suitability.
3. A method that can be repeated and yeild the same result and that can be checked by others.
4. A method that takes into account the physical size and skill and manoeuvres performed by individuals or groups of disabled persons.
5. A method that allows a study of variables and that can show the relationship of various spacial dimensions.
6. A method that is easy to use, is adaptable and that does not involve the use of bulky, or elaborate equipment.

4. Research Method

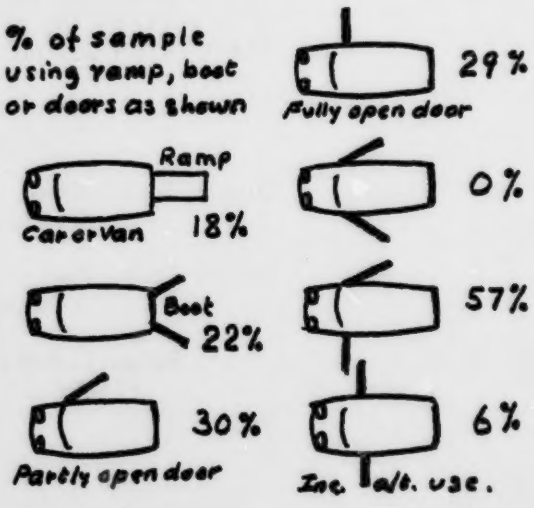
Data on disabled persons, mobility aids, manner of use, skill in use and spacial needs were obtained during the field testing by approximately 250 disabled persons in a wide range of access facilities that included carparks, office areas, water closets, showers, bathrooms, lifts, passages and doorways. Of some 300 wheelchairs examined, 79 where measured to determine the range and distribution of key dimension that affected spacial needs. These data were used to develop a method of calculating user error, wheel chair size and space needs.

4.1 Manner of use of Wheel Chairs Records were kept during field testing of the manoeuvres people used and the final positions of their wheel chairs when they used various facilities such as vehicles, toilets (water closets), basins (lavatories), baths and door levers.

From these data common manoeuvres and common chair positions were determined together with the number and hence the percent of sample that used a particular manoeuvre or chair position. Example of these data are included in Fig. 1 and 2.



Wheel Chair positions for transfer to toilet pan.



Use of and amount car doors need to be open

4.2 Skill in Use of Wheel Chairs Dimensional details of mobility aids and the least space needed by each person to obtain access were recorded during tests. Thus it was possible to reproduce to scale the key dimensional details of the wheel chair used by a particular subject and to find by trial and error, using a scale drawing of the situation or layout tested, the minimum space in which that person could have achieved access had perfect control of the wheel chair been possible.

The difference between actual space needed and the minimum required with perfect control of the same wheel chair was called variance and taken to be a measure of that persons skill in use in that particular situation.

It was found that, when in a limited space, most wheel chair users could achieve an accuracy of about ± 50 mm when positioning their wheel chair. Some persons could position very quickly , others were slow to position and some made a series of minor adjustments when positioning carefully.

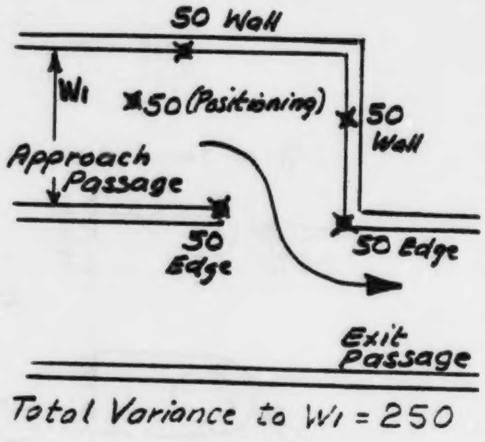
It was also found that variance increased rapidly as the number of walls, door frames or other objects that had to be avoided increased.

From this information a set of rules were developed for desk determination of variance for various access situations that when applied to the cases field tested gave a reliable value for real people.

These rules for variance are shown in Fig. 3 and an example of the use of the rules is shown in Fig. 4.

Manoeuvre		Variance
Stopping foreward		25
Stopping backwards		50
Side positioning near wall		50
Clearing an obstruction		50
Single Loop	Ahead -	25
	To side -	50
Double Loop	Ahead -	50
	To side -	75
Triple Loop	Ahead -	75
	To side -	100

Rules for Variance
FIGURE 3



Example of Applied Variance
FIGURE 4

4.3 Wheel Chair Dimensions It was found that certain diagonal dimensions of wheel chairs were in many cases more important to spacial design than the overall length or width.

The horizontal diagonal length from the ground contact point of a rear wheel to the front opposite corner of the foot rest was particularly significant as was also the horizontal length from the rearmost part of a rear wheel to the front opposite corner of the foot rest.

These vital dimensions are automatically taken into account by use of correctly wheeled ground level silhouette of a particular wheel chair or of one that represents a particular group or percentage of wheel chairs in use.

Our general design concern with respect to a particular task of reviewing the Australian Standard AS 1428 was to arrive at spacial dimensions that would allow access for a reasonable number of wheel chair users. To provide "convenient to use" space in public places for every wheel chair used was seen as both spacially and economically impossible at the present time.

It was decided that access for 80% of known wheel chair users was at this stage an acceptable target and that the need to make up to 3 looping movements for lateral shift of the rear wheels during entrance and again during exit from a confined area, such as a toilet cubicle, was acceptable.

These decisions in effect established design data for facilities easily useable by 80% of wheel chair users. Of the remaining 20% some would be able to obtain access with extra effort and or difficulty; some would need assistance and a few could find access impossible.

The A80 (Adults 80%) wheel chair required for design on this agreed basis was developed as follows.

From a survey of about 300 in use wheel chairs 79 were selected as representative of the range and types that needed to be considered.

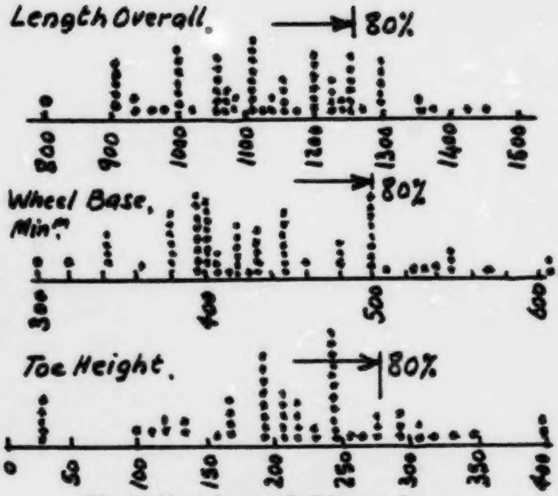
All spacially important dimensions of these 79 wheel chairs were measured.

The range and distribution of each of the measured dimensions were plotted and the derived dimensions that, from the point of view of space needs, included 80% of the chairs studied were selected as the dimensions to be used for the A80 wheel chair. From these basic data other dimensions can be obtained that include or exclude selected percentages of the sample.

Typical derived values for the A80 wheel chair are shown in Fig. 5 together with samples of the range and distribution of measured dimensions in Fig. 6.

Characteristic	Dimension
Length overall	1250
Wheel base	500
Width overall (include a total of 80 for knuckle clearance)	740
Toe Height	280
Large Wheel dia	620
Knee height	660
Arm rest to end of toe	500
Waist to end of toe etc	700

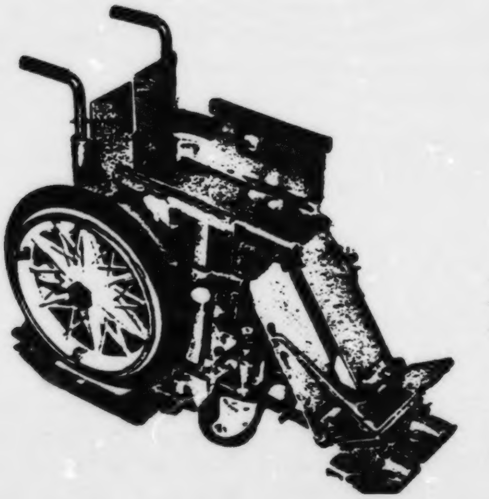
Dimensions of A80 Wheel Chair
FIGURE 5



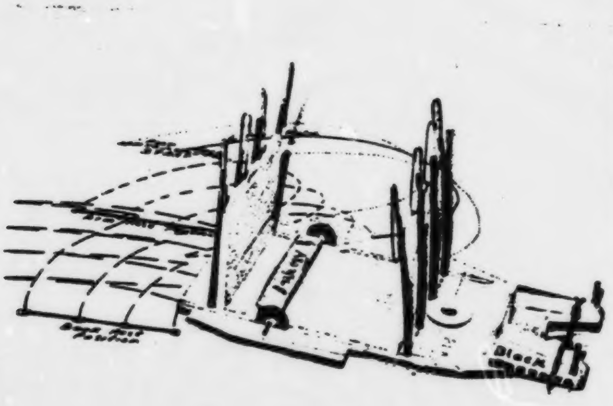
Distribution of Dimensions
FIGURE 6

4.4 Model Wheel Chairs

In a study to check the suitability of AS 1428 and to make recommendations for amendment of that code a 1:5 adjustable model wheel chair was used set to the A80 dimensions. This model with associated ground level silhouettes for foot rests, wheels and hands on propelling wheel is shown in Fig. 7.



Adjustable model Wheel Chair
with silhorether at groud level
FIGURE 7



Silhouette model wheel chair
with markers fitted
FIGURE 8

A silhouette only version of a wheel chair is shown in Fig. 8. This unit adjusts to the horizontal outline of a selected size wheel chair and has a pair of small rear axle wheels only that cause the motion of the chair to be similar to that of a chair with large rear wheels and 2 castered front wheels. This silhouette version can be fitted with markers that trace out the loci of selected parts of the chair as it is monoeurved over a layout placed horizontally as shown in Fig. 8.

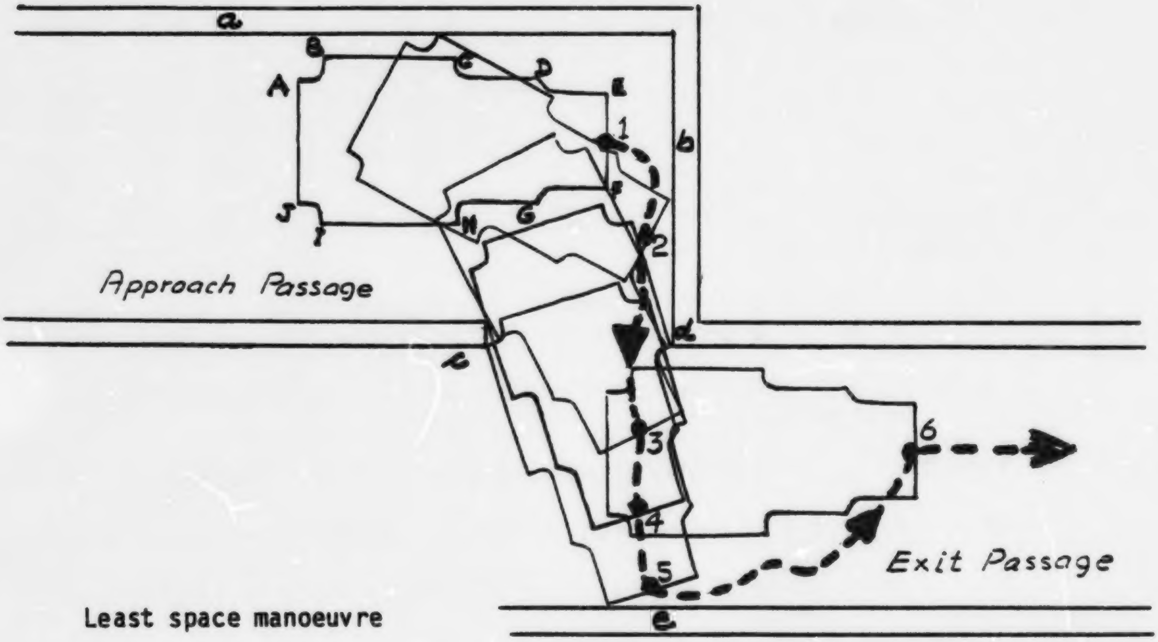
5. Two Dimensional Space Design

The method of using the A80 wheel chair and the method of determining variance are described below for a two dimensional situation involving parallel passageways connected by an 800 door opening through a 100 separating wall and with one passage closed off at the doorway.

The procedure illustrated is typical of that used for other layout situations and for other size wheel chairs that represent particular individuals or groups for whom the design is required.

Using the 1:5 Model A80 wheel chair or wheeled silhouette and a 1:5 scale layout the chair movements to negotiate the layout were determined by trial and error.

Fig. 9 shows the chair movements that were found to take up least space when the door opening was 800.



Least space manoeuvre

FIGURE 9

For record purposes and to allow repeats of the test all that is needed is the layout, the position of the wheel chair at the start of the test and the loci of some forward part of the chair, preferably the mid point of the front of the foot plates which will give a Centre Line Trace as shown in Fig. 10.

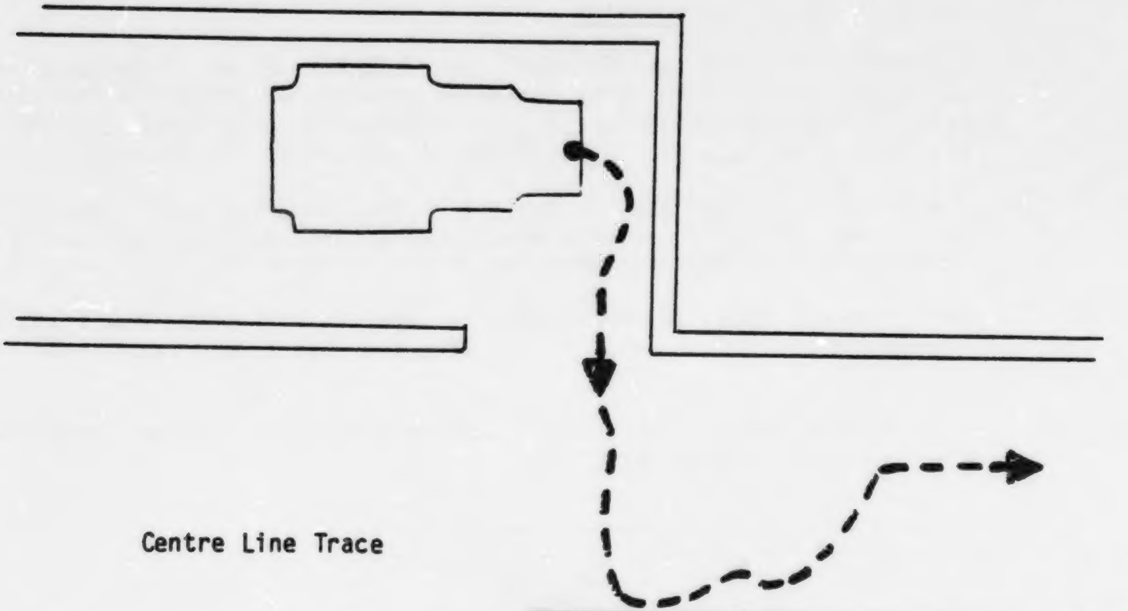


FIGURE 10

The critical situations that occur during these chair movements are as follows:

At 1. Direction and space between chair and side wall "a" is important to allow subsequent movements. This is the starting position.

At 2. Pt B on chair is very close to wall a. Pt E on chair is in contact with wall b.

From 2 to 3. Pt E slides along wall b as Pt B just touches wall a.

At 3. Pt D is in contact with wall at d, and Pt H just touching wall at c.

From 3 to 4. Line BC slides along wall at d, and Line IH slides along wall at c.

From 4 to 5. Sliding contact on each side of chair continues until Pt I is just clear of wall at c.

At 5. Line BC is in contact with wall at d, Pt I is just clear of wall at c and Pt F is in contact with wall at e.

From 5 to 6. With Pt F sliding along wall at e and with Line BC just clearing wall at d the chair reaches a position such as 6. and the S turn is completed.

Applied variance for door opening width of 800, 950 and 1100 were calculated based on the following considerations:

Applied Variance for Approach Passageway (800 door opening)	Variance
Chair positioning at 1. is critical so allow for a positioning error by an actual user of 50mm	50
From position 1. to position 2. and on to 3. the chair swing must be controlled so Pt B just misses the wall a, so allow for a 50mm error in swing	50
During the same movement Pt E must just slide along wall b so allow for a 50mm error	50
From position 3. to 4. the chair must be accurately positioned so contact is just maintained at wall d, so allow 50mm error	50
At the same time the direction of the chair must be correct so line IH slides along wall at c, so allow another 50mm for error	50
Total variance for approach passage with 800 doorway	250

Applied Variance for Exit Passageway (800 door opening)	
During the first part of movement from 4. to 5. the chair direction is critical to maintain contact on both sides of the chair at the one time so allow for an error of 50mm	50
Just prior to position 5. point I will clear the wall at c and the chair can then be swung to make a left hand turn. If this critical turning point is missed the exit passage needed will be wider than otherwise required so allow a positioning error of 50mm	50
As the chair is turned past position 5. Pt F must just touch the wall at e and for user error allow 50mm	50
During this turn Pt J will be well clear of wall c and the chair will move away from wall d so no allowance needs to be made for error	0
Total variance for exit passage with 800 door opening	150

By similar analysis for a doorway width of 950 it is found that provided all other critical contacts are maintained, as above, contact with the wall at c is no longer required during the approach phase but is still required during the exit phase. Thus the total variance for the approach passage is 250-50 =	200
and for the exit passage it remains at	150

	Variance
With a doorway width of 1100 contact with wall b is no longer critical nor is contact with wall c for either the approach or the exit phase. Thus the total variance to the approach can be reduced a further 50mm to give 200-50 =	150
and for the exit also reduced by 50 to give 150-50 =	100

These variances so determined can be shown as follows:

Variance for S turn

	Doorway Width		
	800	950	1100
Approach passage	250	200	150
Exit passage	150	150	100

By plotting these values, variances for intermediate doorway widths can be determined. For door widths greater than 1100 use the value of variance for door width 1100.

In applying the above variances we are in fact stating that the minimum size passageways needed for access by an A80 wheel chair, using the best possible manoeuvres and under perfect control, should be increased by an amount equal to the variance. This will allow access to be obtained by actual chair users who cannot be expected to position and manoeuvre their wheel chairs so precisely as was effected in tests with the A80 wheel chair.

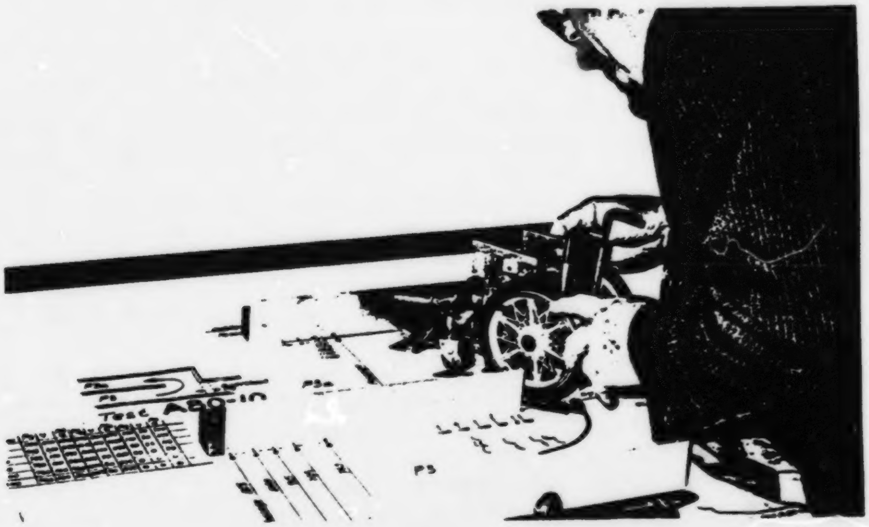
Using the A80 wheel chair to find minimum passage width with various door openings gave the results below and allowed the minimum design dimensions for use in practice to be determined as shown:

	Door opening					
	800	900	1000	1100	1200	1300
Minimum approach passage width W1 needed by A80 wheel chair	1080	900	795	740	740	740
Applied variance	250	210	180	150	150	150
Design width W1	1330	1110	975	890	890	890
Minimum exit passage width W2 needed by A80 wheel chair	1005	940	895	860	830	780
Applied variance	150	150	130	100	100	100
Design width W2	1155	1090	1025	960	930	880

6. Three Dimensional Space Design

Where most elements in a space have already been located the Direct Method is recommended. Where flexibility in equipment location exists then the Profile Method is generally the more convenient method to use.

6.1 The Direct Method. In this method a 3 dimensional scale model wheel chair is used with a 3 dimensional scale layout as illustrated in Fig. 11.



THREE DIMENSIONAL TESTING

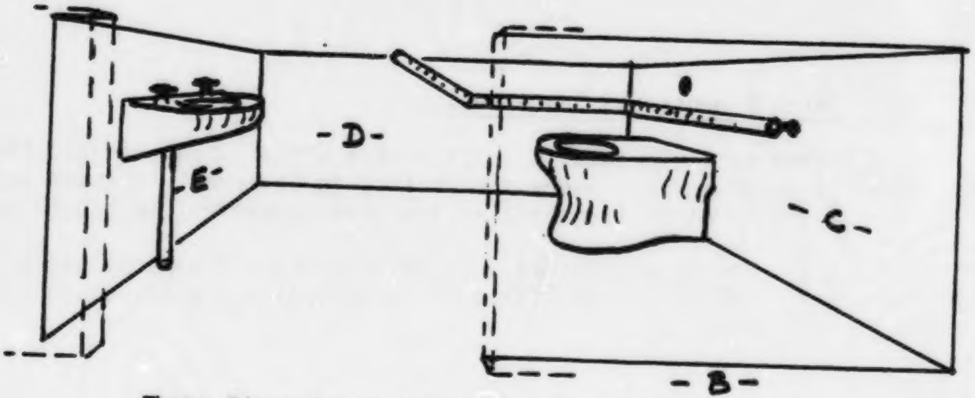
FIGURE 11

In the case shown in Fig. 12 each of six chair positions for transfer from the wheel chair to the pan as shown in Fig 1 were considered separately to determine minimum space needs.

With doorway, pan size and position, basin size and position and walls B and C fixed, the walls D and E were moved to just permit the model wheel chair to be moved to allow the various transfer positions to be reached and for the chair to exit forwards out of the space.

Initial chair positions on entry and centre line traces were made for each case for record purposes and to allow subsequent checking.

Applied variance was added to the minimum width and length needed by the model chair to obtain design width and length.



Three Dimensional Layout for pan Cubicle

FIGURE 12

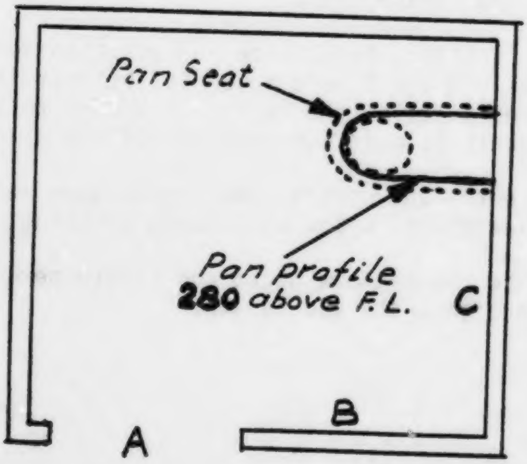
The Direct Method is ideal for checking a layout where the positions of most elements, that influence space needs, have been decided.

It is often found during such tests that the relocation of a particular element (for example, a hand basin) would make access and use easier and require less overall space.

To overcome this type of problem the Profile Method was developed.

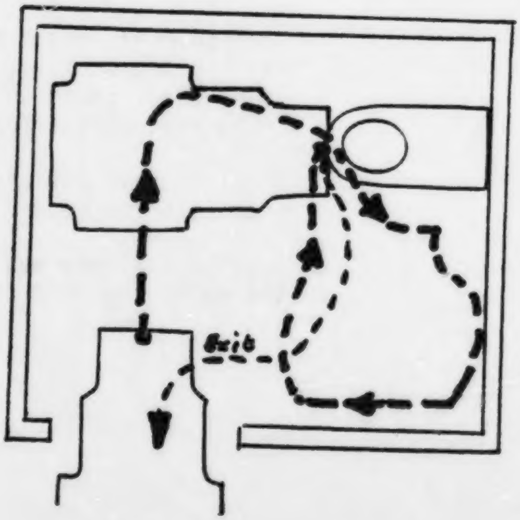
6.2 The Profile Method. This method uses a 2 dimensional scale model wheel chair fitted with markers that trace out the loci of those elements of the wheel chair and user that interface with walls and equipment in the space. This chair is used with a scale layout that includes lines showing the horizontal outline at contract level of all equipment in the space that is not subject to relocation.

In Fig. 13, doorway A, wall B and C and the position of the pan seat and the profile of the pan pedestal at 280 above floor level are shown. With an A80 wheel chair the toe height is 280 and it is this part of the wheel chair that needs to clear the pan pedestal during manoeuvres.



Interferrence Layout

FIGURE 13



Centre Line Trace

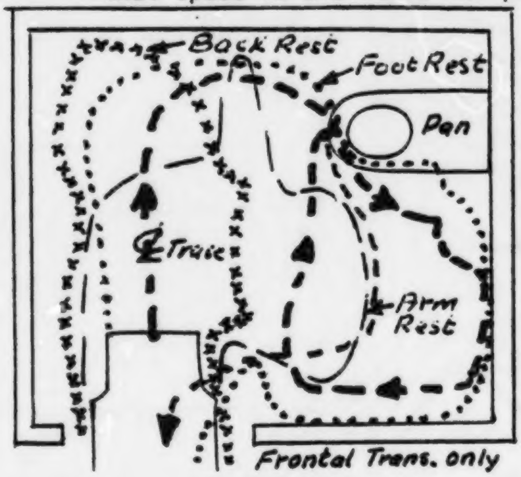
FIGURE 14

With this layout the two dimensional chair is moved through all required manoeuvres that take up least space while the markers trace out the loci of all important elements of the wheel chair.

Fig. 14 and 15 illustrate typical traces for a frontal transfer to the pan followed by forward exit from the space.

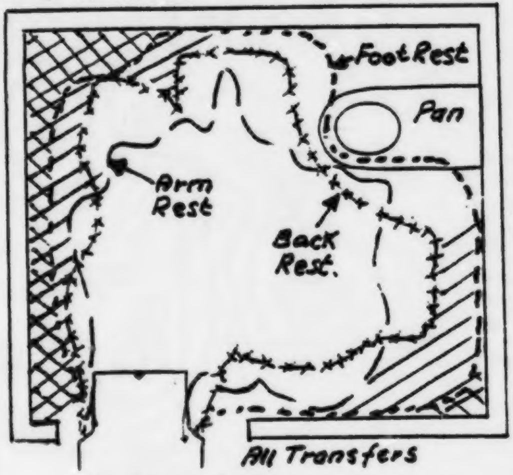
The various traces so obtained are combined as shown in Fig. 16 to find the loci of key elements of the wheel chair within which all required manoeuvres are possible.

Knowing the active height range for each loci it is easy to identify what space is available for positioning equipment in the area.



Trace of loci

FIGURE 15



Combined loci trace

FIGURE 16

As an example the down pipes from basins must clear the loci of the footrest while the basin bowl can extend over this loci but must clear the loci of the arm rests and the back rest of the wheel chair.

The double and single hatched area in Fig. 16 shows the available space for hand basin bowl location and the double hatched area shows where down pipes and other low level items can be located.

7. Spacial Design Technique in Use

The following expamples of use of the Spacial Design Technique illustrate the flexibility and problem solving ability of this method of design.

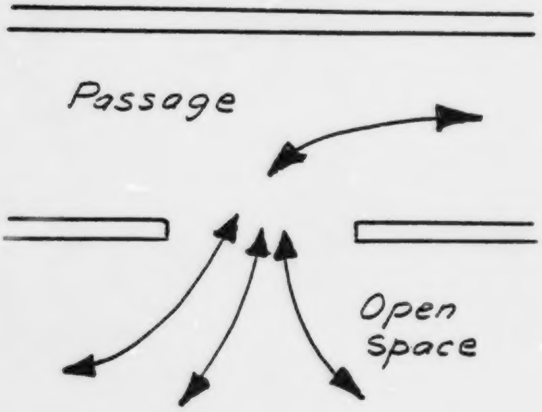
7.1 Passage Way Design

Problem : For a doorway openingfrom a free space through a 100 thick wall to a passage way running at 90° to the doorway what is the relationship between door opening and passage width that will allow free flow access each way by 80% of known wheelchair users. By free flow we mean continuous movement in the direction of travel without the need to backaway or perform looping movements to effect lateral shift of the rear wheels. See Fig 17.

Solution : Use of the scale model A80 wheelchair, scale layout and applied variance gave the following design values.

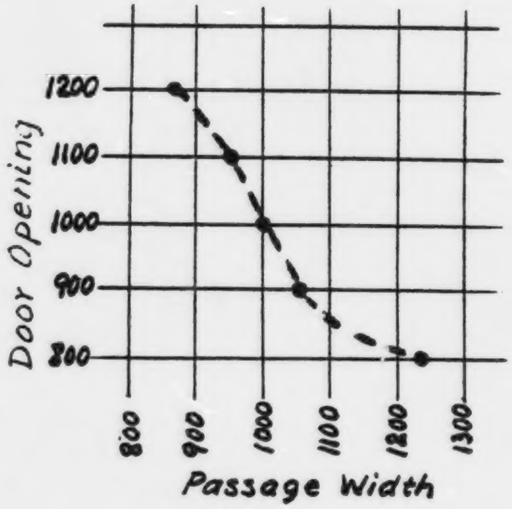
Door Opening	Required passage width Free space to passage	 Passage to free space
800	1230	1235*
900	1060*	1040
1 000	1000*	930
1 100	955*	840
1 200	875*	840

For two way access the values marked are selected to give the graphical solution shown in Fig. 18



Movement between open space and passage way

FIGURE 17



Relationship between door opening and passage width

FIGURE 18

7.2 Lift Car Design

Problem : What is the minimum size lift car that, with centred 880 door opening and with control buttons on one side wall only, is accessible to 80% of wheelchair users with forward entry and exit and with no more than 3 loop movements being required during entry and again during exit. What effect has door position on car size.

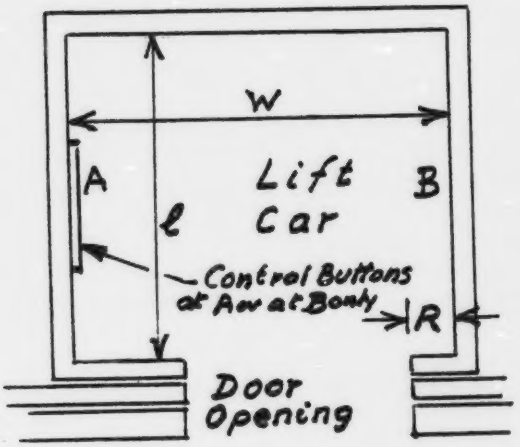
Note The aim of these requirements is to ensure that a wheelchair user, alone in a lift, will be able to manoeuvre to reach the one set of control buttons even though some time and inconvenience might be involved. The aim is not to provide for an easy 180° turn within the lift. See Fig 19.

Solution : A series of tests were conducted for each door position using a scale layout and scale model A80 wheelchair with hand reach indicators for control button access.

It was found that a clear length of 1580 was needed to allow looping manoeuvres.

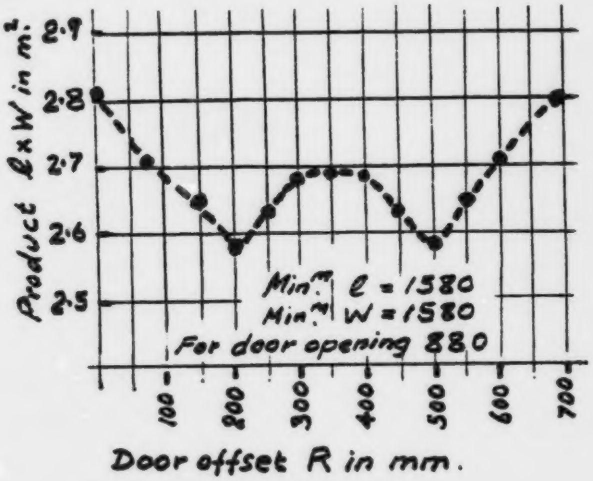
It was also found that minimum space was used when the chair user started a turn from a position close to but clear of a side wall and performed a series of backing movements as the turn progressed such that at the end of a 180° turn the wheelchair was backed up to the rear wall of the lift car.

Test results were used to show the relationship between door position and clear lift car floor area and a minimum lift car length and width as illustrated in Fig. 20.



Lift car with offset door

FIGURE 19

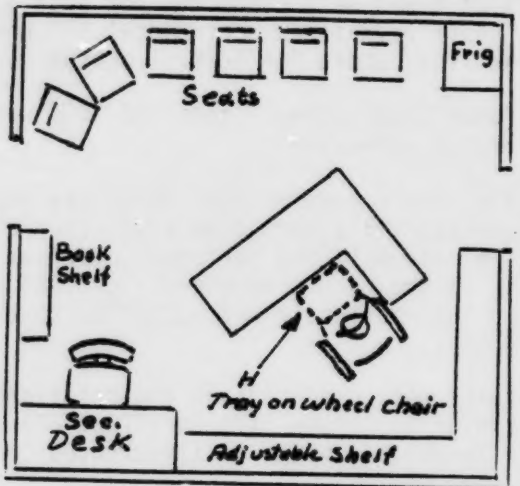


Relationship between door offset and lift car size

FIGURE 20

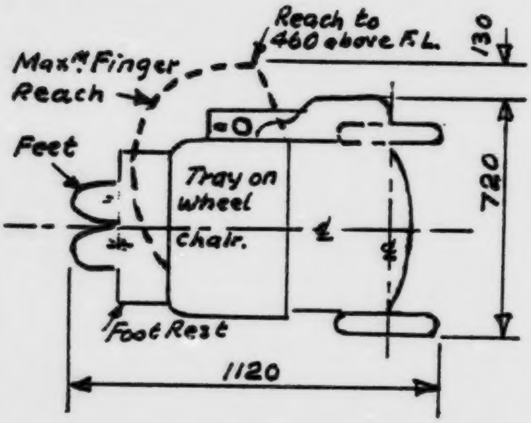
7.3 Office Layout Design

Problem : What is the most accessible arrangement of the equipment and layout shown in Figure 21 for a Senior Executive who uses the electric wheelchair and has the limited right-hand only reach shown in Figure 22. What special furniture would assist this executive to perform office functions including use of intercom, access and reading and disposal of files, hand writing, dictation and interviewing both able and disabled persons.


Frig
Seats
Book Shelf
H
Tray on wheel chair
Sec. Desk
Adjustable Shelf

Initial Office Layout

FIGURE 21

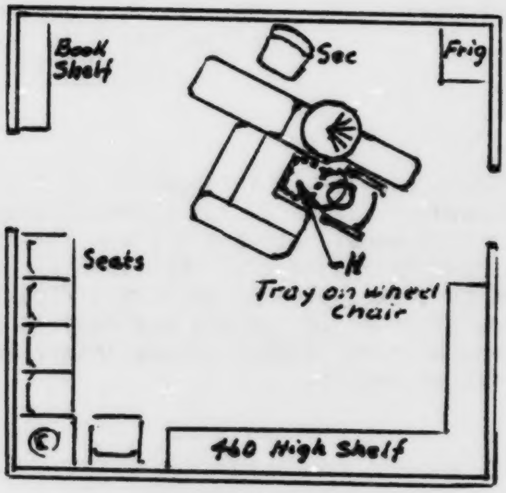

Reach to 460 above F.L.
130
Max.m Finger Reach
Feet
Tray on wheel chair.
℄
720
Foot Rest
1120

Users Wheel Chair and
R.H. Finger Reach
FIGURE 22

Solution : A two dimensional scale model wheelchair with hand reach indicator and proposed layouts were used initially to determine manouvering spacial needs and areas of reach for the executive.

The two dimensional scale model was then set to A80 size to determine the spacial needs and access requirements of visitors.

The data so obtained resulted in the layout being altered to that shown in Fig. 23.

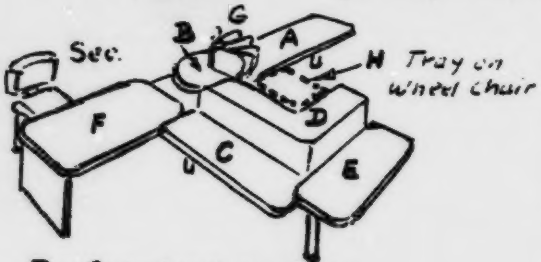

Book Shelf
Sec
Frig
Seats
H
Tray on wheel chair
460 High Shelf

Recommended Layout

FIGURE 23

Surface	Height	Surface	Height
A	460	E	760
B	480	F	700
C	600		
D	820		

All surfaces height adjustable


Sec.
B
G
A
H
Tray on wheel chair
D
F
C
E

B - Rotating surface
G - File holder, on item B

Recommended Desk

FIGURE 24

Working surfaces and shelves were then designed in plan to suit the executive and visitor needs.

Under clearances were determined and best work surface heights decided.

Support systems for working surfaces and shelves were then designed to give needed stability and avoid interference with the movement loci. Finally a 3 dimensional scale layout was used with a 3 dimensional scale model wheelchair set to the sizes shown in Fig. 22 and later to A80 size to check suitability for the executive and visitors.

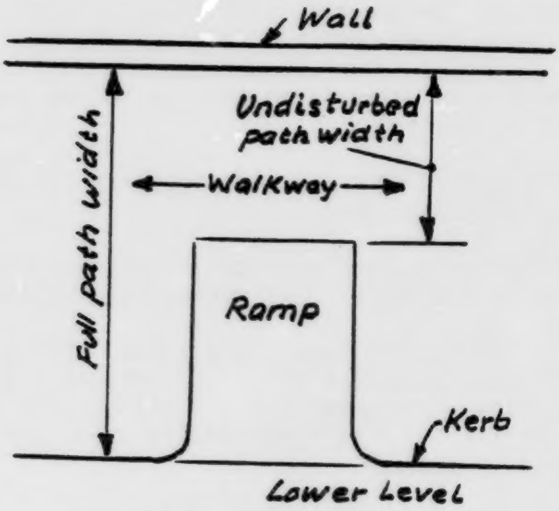
The desk arrangement shown in Fig. 24 was recommended.

7.4 Path Width Design

Problem : A short cut in ramp is to be used for wheelchair access between a footpath with a wall to one side and an adjacent flat open area at a different level.

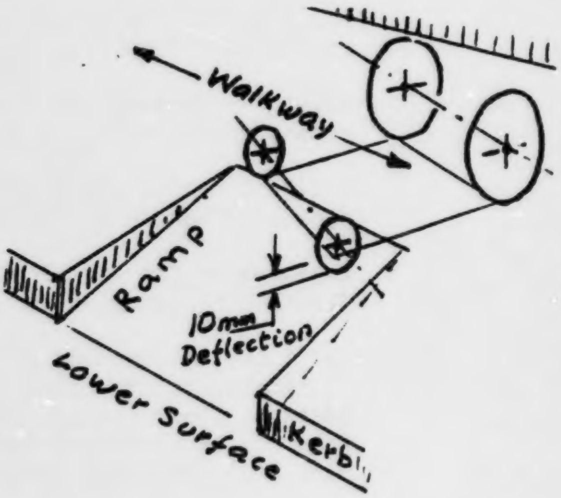
What undisturbed path width is needed for access by an A80 size wheelchair if the ramp is 1100 wide and alternatively 900 wide.

What undisturbed path width is needed if it is assumed a 10mm deflection of one wheel of the wheelchair is acceptable with a ramp width of 1100. See Fig. 25 and 26.



Kerb ramp and walkway

FIGURE 25



10mm deflection of one wheel

FIGURE 26

Solution : The various undisturbed path widths were determined firstly experimentally using a 3 dimensional model wheel chair set to A80 size and secondly by mathematics, as is possible in this case, as a check on accuracy The values so obtained were as follows.

	RAMP WIDTH 900	RAMP WIDTH 1 100	RAMP 1100 WIDE ALLOWING 10mm DEFLECTION
Undisturbed Path Width need by A80 Wheelchair	1145	1145	1055
Variance	195	125	125
Design Width	1340	1270	1180

8. Summary

There is a need for better methods of determining the space requirements of wheel chair users. Existing codes and practices and existing experience are not always sufficient to ensure good design. Research was directed towards developing an easy to use, repeatable design method that took into account both user and space variables and considered the relationship of spacial dimensions. In the research, field testing data were used to identify basic wheel chair manoeuvres, skill in use of mobility aids and wheel chair dimensions.

Adjustable three dimensional and two dimensional silhouette model wheel chairs were developed for use in space design.

Rules for determining variance were established that reflected the user errors found in full size field testing.

A direct method and a profile method of spacial design were found to be needed to handle differing design problems.

Examples of the use of the spacial design technique illustrate the flexibility and problem solving ability of this method of design.

Too much space can be as inconvenient to some users as too little space is to others. By using this spacial design technique designers know the basis of their design, they know which wheel chair users it will suit and they can be confident the facility will be functionally sound and funds used will have been economically applied.

AUTO-RIDE - A VIDEOTEX-BASED, PARATAXI SYSTEM

Low Cost, Door-to-Door, Transit Services

Robert W. Behnke - Aegis Transportation Information Systems
Malcolm McLeod - Hawaii Department of Transportation

> "Prospects are promising for an urban transportation system that combines private use of private automobiles with public use of public automobiles and other shared vehicles that use streets and freeways. . . .No brave-new-world transport technology is called for. No shiny trains and ornate subway stations. Merely prosaic buses, vans, and automobiles operated more intelligently.
>
> We have already evolved the world's most effective transport system, and it already offers extraordinary mobility to a large proportion of Americans. It is not new vehicle types that we need. Nor do we need to spend a lot of money to create a lot of new travelways.
>
> Our task, instead, is to extend automobility to those who do not yet enjoy it and to do so without unduly increasing congestion, pollution, or energy consumption. We need neither huge investment in outdated rail technology nor a Manhattan project to develop post-modern new transport technology.
>
> We already have plenty of roads and plenty of underused vehicles. We just need to manage those resources more effectively and more equitably. (005)"

The above statement was made by Dr. Melvin Webber, Institute of Urban and Regional Development, University of California - Berkeley, at the Governor's Conference on Videotex, Transportation and Energy Conservation in Honolulu.

The advent of new telecommunications services, such as videotex, will provide transportation agencies with new capabilities that can help make Dr. Webber's vision a reality. Easy-to-use videotex terminals will permit communities of almost any size to integrate buses, vans, taxis and private automobiles into a low-cost, door-to-door public transit system.

In addition to increasing the mobility of all citizens, including the elderly and handicapped, a community videotex system can provide residents with a variety of new recreational, educational and employment opportunities. Most of the costs of installing a community videotex system will be paid by advertisers and local businesses.

This paper describes videotex, the AUTO-RIDE parataxi concept, and how they can complement and supplement conventional transit, paratransit and ridesharing services. it presents the major findings of a study conducted for the State of Hawaii, using Federal Highway Administration (FHWA) funding, to analyze the potential of videotex to reduce a variety of transportation, energy and environmental problems. The State of Hawaii is now organizing a public-private partnership to test the AUTO-RIDE concept in a community of approximately 25 thousand residents.

The following statement was made by Dr. Martin Wohl, Professor of Transportation System Planning at Carnegie-Mellon University and one of the authors of the RAND Corporation Report "The Urban Transportation Problem"

> The goals of urban transportation are so often viewed as reducing downtown traffic congestion, improving suburban-to-downtown commuting, and "getting people out of cars into transit." We look too little at the ultimate purpose, which is fast, efficient transportation. The most talked about "means" for reaching our goals usually include the construction or extension of suburban rapid transit lines as well as subsidies for new and existing facilities, transit fare reduction (if not free transit), the banning of automobiles in the downtown area, parking fee surcharges, and congestion tolls for autos. This kind of rhetoric rarely gains us more than heavy capital commitments for new or extended transit lines, new but still conventional buses or rail cars, and heavier transit deficits. Traffic congestion is not reduced; transit service seems little better - at least for most urban dwellers - and the problems of pollution, noise, and energy consumption remain unabated.

Dr. Wohl has been a long-term advocate of changing taxi regulations to improve the availability, usage and financial viability of these paratransit vehicles. By eliminating regulations against shared-ride taxi services, for example, cab owners could not only increase profits, they could also reduce fares and conserve fuel. This, in turn, would provide important benefits to those aged and handicapped riders who need door-to-door transportation services and guaranteed seating.

Mass transit systems and carpools are making an important contribution to energy conservation. However, it is doubtful that this contribution will increase in the future. Although public transit systems received billions of dollars of federal and state aid between 1969 and 1979, the percentage of commuters who use rail and bus services decreased from 10 percent to 6 percent during this period. (179) This is a 40 percent loss in transit's market share during a decade in which there were two gasoline crises and the cost of owning and operating an automobile increased dramatically. During this same decade, despite an extensive campaign to encourage carpools, there was an overall increase in the use of single-occupant automobiles for commuter travel. To paraphrase Honolulu columnist Lois Taylor: "Carpools are like broiled liver - cheap, good for you and unpopular. To date, despite bumper sticker propaganda to the contrary, they don't work for most people."

Some conservationists may question the preceeding statements about the limited energy saving potential of both carpools and mass transit. It should be noted that these conclusions were developed by both Alvin Alm and Daniel Yergin in their studies of U.S. transportation-energy problems. It should also be noted that both of these studies were completed before President Reagan took office and announced plans to reduce federal spending on public transportation.

In 1970, our national bill for imported oil was $3 billion. In 1978, it was $42 billion. In 1980, even though conservation efforts and the recession significantly reduced the volume of oil imports, the price for these imports exceeded $80 billion. This is equivalent to every family of four sending $1,600 out of this country every year and it is a major reason for our country's inflation and balance-of-payments problems.

The transportation sector uses approximately half of the oil used in the United States and the private automobile consumes over half of this amount. The American car alone consumes one-ninth of all the oil used in the world every day. The improvement in the mileage efficiency of the automobile population will make an increasing contribution to the U.S. energy conservation program. To make a similar contribution in our transit systems, it will be necessary to broaden our concept of ridesharing to include non-commuter travel and vehicles operated for a profit. It will also be necessary to broaden our concept of public transit to include a variety of new, innovative transportation services.

Because of our continued dependence on imported oil, our increasing transportation and enviromental problems and the proposed federal cutbacks in operating subsidies for transit and carpooling operations, a growing number of transportation specialists are recommending that regulations also be changed to permit individuals to use their own personal vehicles to supply local transportation services on a quasi-business basis. Unlike carpools and vanpools, which must be operated on a not-for-profit basis, the proposed "paraprivate" transportation services would generate income for driver-owners. This approach could add enormous transportation capacity at little or no additional cost to the public. Dr. Ray Mundy, Professor of Marketing and Transportation at the University of Tennessee, and the person who coined the term "paraprivate" transportation, offers the following commentary:

> Management of public transportation systems in the 1980s will be a major challenge for urban areas. Their operating scenarios, financial support, and general feasibility will be severely tested. The present heavy subsidy of transit is not expected to continue. Just as much of the U.S. industry has had to specialize its product offerings in a competitive market place, so will transit systems. This will mean the expansion of paratransit activities and the inclusion of paraprivate transportation options. ...How these newer, specialized forms of public transportation alternatives are integrated into existing

> traditional transit operations will be the major managerial and official focus for much of this decade. Those areas that are successful in broadening their concept of public transportation to include these innovations will breathe new life and vitality into their local transportation systems. Those who do not will continue to teeter from one financial crisis to another. Clearly, public transportation officials at all levels need to ask themselves, "What are we trying to do?", and restructure to accomplish these goals. We can no longer continue to use nineteenth-century work rules and early twentieth-century technology as we stumble toward the twenty-first century.

The microcomputer, a prime example of late twentieth century technology, provides some new tools to help public transportation officials integrate transit, paratransit, ridesharing and paraprivate resources into a more cost-effective, more energy-efficient transportation system. Aegis Systems Corporation, for example, has designed an automated, door-to-door transportation system, called AUTO-RIDE, that utilizes low-cost videotex terminals to rapidly match would-be riders with would-be drivers on a trip-by-trip basis. AUTO-RIDE is a supplemental transportation service that attempts to combine the comfort and convenience of the taxi with the economy and energy conservation characteristics of the carpool. The advent of the microcomputer and videotex makes AUTO-RIDE a technically feasible concept today.

Videotex is the name given to an easy-to-use, two-way consumer information delivery system. Users in homes, offices and shops can call information from a variety of remote sources and display it on an ordinary TV set using a low-cost, microcomputer keyboard. The information carrier can be either a telephone line, TV cable or a radio link. Once installed in a community, a videotex network connects businesses and homes creating a new two-way video communications medium in which users can make reservations, purchase goods, pay bills, receive training and exchange electronic mail. Perhaps the most widely publicized application of this technology is the French government's program to install 270,000 videotex terminals in a suburb of Paris to replace printed telephone directories and reduce the cost of directory assistance services.

The AUTO-RIDE System employs low-cost, easy-to-use videotex terminals to instantly collect trip requests from riders and trip offers from drivers. Because of the speed and flexibility of the modern microcomputer, detailed trip information (e.g. origin, destination, departure time, seating) can usually be entered by pressing one or two buttons on the terminal keyboard. This information, after being checked for accuracy and completeness, is then automatically transmitted to a central computer. After careful security checks are performed, the central computer matches drivers and riders to instantly form, in effect, single-trip carpools. Confirming and coordinating messages are then transmitted back to the terminals for the drivers and riders.

It is envisioned that the AUTO-RIDE System will use a mix of professional taxi drivers and part-time drivers to provide demand-responsive (i.e. on-call) transportation services. Fares, comparable to those of existing public transit systems, will be billed monthly by the central computer. Since only a small portion of these fares will be needed to support the central computer system, most of the fares can be used to provide financial incentives for AUTO-RIDE drivers and to subsidize operators of taxi-cabs or specialized vehicles for the handicapped.

The State of Hawaii and the City and County of Honolulu are national leaders in energy conservation and in the use of both carpools and public transit. In a Bureau of the Census report (140) that analyzed travel to work in 20 U.S. metropolitan areas, Honolulu led all cities in the percentage of commuters using carpools and was second only to New York City in the percentage of commuters using public transit. Honolulu's current ridership levels are actually higher than the long-term ridesharing and transit ridership goals of some mainland cities. Nevertheless, Honolulu has serious traffic congestion problems that are getting worse every year.

In 1975, Hawaii's Department of Transportation started a series of seminars to consider ways to limit the number of vehicles on the island of Oahu, that is, in the City and County of Honolulu. (013) Dr. Ryokichi Higashionna, now the Director of the Department of Transportation - State of Hawaii, pointed out at that time, that it would be unrealistic to attempt to limit the number of automobiles on Oahu until an alternative method of transportation was available to the public. Without a cost-effective public transit system, the various tax disincentives that were proposed to reduce the number of automobiles on Oahu would have placed a disproportionate financial burden on the poor. Both the State of Hawaii and the City and County of Honolulu have been conducting evaluations of a variety of transportation concepts in an attempt to develop a more cost-effective public transit system for Oahu.

In February 1982, Aegis Systems Corporation was awarded a contract by the Department of Transportation to conduct a six-month study of the costs and benefits of installing a videotex-based ridesharing system on Oahu. The following are the major conclusions of this study:

- A real-time rideshare matching system, such as AUTO-RIDE, is both technically and economically feasible for Oahu.

- The door-to-door features of AUTO-RIDE are mandatory for many young, elderly and handicapped riders, and very desireable for most others. Like the taxi, AUTO-RIDE offers riders a level of service that is competitive with the automobile for both commuter and non-commuter travel. It also eliminates parking and driving chores.
- By providing a feeder service in the more remote areas of Oahu, AUTO-RIDE can stimulate use of bus services. By providing convenient back-up transportation, AUTO-RIDE can also stimulate the use of commuter carpools and vanpools. On rainy days it will help those who normally walk or bike to work.
- Videotex terminals can be used to provide current information on the arrival times of buses at any bus stop. Computerized Rider Information Systems (CRIS) have already demonstrated the ability to increase off-peak ridership on fixed-route bus systems. The terminals can also be used for a variety of "third wave" applications, such as home-banking, electronic-mail, shop-at-home and telecommuting.
- AUTO-RIDE can increase full-time employment opportunities in both public and private transportation and in a variety of high-technology industries. It can also increase part-time employment opportunities for a large number of vehicle owners who are willing to provide rides to neighbors, co-workers and other qualified residents.
- AUTO-RIDE can complement and supplement existing transportation services. Its videotex terminal network can help integrate transit, paratransit, ridesharing and paraprivate resources into a more cost-effective, more energy-efficient public transportation system.

- An integrated, multi-modal public transportation system can reduce Oahu's dependence on both the one-person auto and imported oil. It can increase the mobility of the transportation disadvantaged. It can also reduce traffic congestion, air pollution, parking problems and government spending on transportation projects.
- AUTO-RIDE will become even more cost-effective in the future as the cost of electronic equipment decreases and the cost of building and and operating conventional mass transit systems increases.

The following are the major recommendations of this study:

- Hawaii should broaden its concepts of both ridesharing and public transportation. Ridesharing should not be limited to carpools and vanpools; public transit should not be limited to mass transit.
- Regulatory obstacles to innovative paratransit and paraprivate systems should be eliminated.
- Equitable insurance arrangements and fare structures should be developed for operators of paratransit and paraprivate vehicles.
- An AUTO-RIDE system feasibility study should be conducted for each of the major neighbor islands.
- Hawaii should support the development of a prototype AUTO-RIDE system with 10,000-15,000 videotex terminals somewhere in the United States to test the concept operationally.

THE IMPACT ON VEHICLE ROUTING OF VARIOUS OPERATIONAL RULES OF A TRANSPORTATION SYSTEM FOR HANDICAPPED PERSONS

By

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Introduction

This article presents the first results of an ongoing study on the impact of various operating scenarios on the construction and quality of routes in a system for the transportation of the handicapped. The study was begun by the University of Montreal's Transportation Research Centre in 1984 and draws on the resources of two different research teams at the Centre. The procedure used for the construction of routes and schedules is based mainly on two algorithms which were previously developed by these teams and which have been (or will be shortly) described in detail in separate publications. The first algorithm, begun in January 1982, is specifically aimed at the construction of routes and schedules for the transportation of the handicapped [7]. The second, which was begun in June 1983, deals with the more general problem of optimization in the construction of routes and schedules for a vehicle fleet [3], [4]. In our procedure, this algorithm is used to improve on the routes produced by the first algorithm. Based on the fundamental differences presently existing in the operations of transportation services for the handicapped in large Canadian cities, five operating scenarios were then developed. The purpose was to compare the resulting productivity and quality of service for the same day's work under each of the five scenarios, using our procedure to construct the routes and schedules.

This article is divided into seven sections. The first section describes the five scenarios analyzed. The second explains the operating rules (i.e. request classification, reservation and cancellation rules, etc.) of the transportation system to be simulated. The third section presents the data used to simulate a working day. The fourth explains the nature and roles of the algorithms making up the route construction procedure. Sections 5 and 6 describe the results obtained for the two scenarios studied so far. Thus in section 5, the different ways in which the procedure must be applied to each scenario is discussed. Section 6 compares the results obtained for these scenarios focussing on the resulting productivity and quality of service. Finally in Section 7, we conclude by outlining the work which remains to be done and by summarizing the main problems encountered so far.

1. The scenarios

Two features of presently operating transportation systems seemed to us important in characterizing the differences between these systems. The first of these concerns fleet composition, and the second the method of handling service requests from occasional users.

Presently, two types of vehicles are generally used for the transportation of the handicapped : minibuses and conventional taxis. Minibuses can carry several users at once but are costly to operate. The conventional taxi is cheaper but has limited capacity and is not suitable for all users. In some cities, the practice of using minibuses exclusively is currently being questioned. For example, in Montreal, pilot studies on the use of taxis are being carried out in certain parts of the territory. In other cities, such as Quebec, taxis are used on a regular basis. Obviously, however, minibuses* will always be required for users unable to travel by taxi. Nonetheless, we have chosen three alternative working hypotheses concerning the type of vehicles used to transport users : 1) the use of a fleet made up entirely of minibus 2) the use of a fleet made up entirely of taxis 3) the use of a mixed fleet, representing a compromise between the two previous options.

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* or other vehicles adapted to the needs of the handicapped.

There also appear to be two variants in the method used to handle advance requests from occasional users. In one policy, used for example in Toronto, the request is noted down at the time the user calls and the user is called back later to confirm the service and time of departure. In the second policy, used in Montreal, a response is given to the user at the time of calling. The first policy simplifies route planning, but involves a complex and costly call-back procedure. The second policy avoids this costly task, but necessitates an immediate analysis of the request. It is difficult to choose between these two approaches except when taxis are used for all users capable of travelling in this type of vehicle. In this case, route planning becomes a relatively simple matter and it would be superfluous to consider call-back procedures. We therefore define the five possible scenarios described below.

Scenario number	Vehicles used to carry users able to travel by taxi :	Advance request handling policy :
1	minibuses	call-back
2	minibuses	no call-back
3	taxis	no call-back
4	minibuses and taxis	call-back
5	minibuses and taxis	no call-back

2. Transportation system operating rules

The data used in our tests to simulate a working day was derived from the Toronto Wheel-Trans service. The operating rules adopted for the simulation were however less restrictive than those currently in place in Toronto, as we wanted to ensure compatibility with the experience of as many cities as possible. This approach also enables us to adopt a planning rather than an operations focus.

We first distinguish two types of requests : regular, and occasional. A request is regular if it belongs to an established list of requests which recur at regular intervals. A typical regular request would be for transportation from home to work (or the reverse) every day of the week, or for transportation from home to university every Wednesday morning for example. All requests which are not regular are classified as occasional. These requests may be formulated on the day of service, but it is recommended that they be formulated a few days beforehand. To model this, we have defined a horizon of three periods, preceding the day of service during which occasional requests may be formulated. In our simulation, these periods correspond to the three days prior to the day of service, but if desired they could be made to correspond to longer or shorter periods. During the three days prior to the service day, users may place their request by telephoning the request handling service between 9:00 a.m. and 6:00 p.m. To encourage advance reservations and to allow the evaluation of the fleet size necessary to service demand, we decide to guarantee service to all requests formulated before the service day. This implies therefore that our request planning problem is not to determine who will be transported, but to define when and along what route the transportation will be carried out. Furthermore, the number of routes and consequently the number of pieces of work are fixed by the list of regular requests and advance booked occasional requests. We offer no guarantee that same-day requests will be accepted. These may be formulated by telephone to the request handling service between 9:00 a.m. and 6:00 p.m. as long as the time of calling is at least 1 hour before the service time required if this is a departure request or at least 2½ hours beforehand, if it is an arrival request. Requests of this type will be immediately confirmed or refused depending on the possibility or not of inserting it immediately into the routes already constructed to satisfy requests called in prior to the service day. The flexibility of our booking policy as well as the choice to guarantee advance reservations, allows us to avoid assigning priorities to requests (depending on the motivation for trips) as is done in certain cities.

We also consider the fact that requests may be cancelled after booking. The rules for this are simple. Any request, regular or occasional, may be cancelled by calling the cancellations service between 5:00 a.m. and 6:00 p.m. (the telephone number is different from the one for reservations). Cancellations cannot be accepted less than 1 hour before service time for a departure request or 2½ hours beforehand for an arrival request. This flexible cancellations system allows us to assume that the "no-show" phenomenon (i.e. users who are absent when the vehicle arrives to pick them up) will be reduced to a minimum. (A system of penalties in which service is not guaranteed for those users who repeatedly do not show up could also be envisaged.)

A maximum capacity was established for the minibuses and taxis. It was assumed that minibuses contained seats for up to 6 passengers and space for up to 5 wheelchairs. For taxis, we assumed a limit of 3 passengers with 2 folding wheelchairs. Finally, we assumed that the minibuses were equipped with radio telephones allowing the operations service to communicate with drivers concerning modifications to the route caused by cancellations and last minute requests during operations.

3. Data used to simulate a working day

To simulate a working day, we used a data file describing the requests used to plan operations on January 27 1983 for the Wheel-Trans Service in Toronto. The file includes 1096 requests made up of 410 regular requests and 686 occasional requests each corresponding to a single journey (i.e. in one direction only). The following information is available on each request :

- request identification (client number)
- name of group or client
- address of origin
- destination address
- service type required (arrival or departure)
- number of passengers (including the number who are ambulatory, the number of wheelchairs and the number of accompanying people
- service time required.

This information had to be completed by simulation to determine which of the requests correspond to possible taxi trips, as well as the days on which the occasional requests were called in. In this simulation, we assumed that half of the users in wheelcahirs used a folding chair and can therefore travel by taxi, and we distributed the 686 occasional requests as follows :

190 requests formulated at D3 (i.e. 3 days before the service day)
190 requests formulated at D2 (i.e. 2 days before the service day)
190 requests formulated at D1 (i.e. 1 day before the service day)
116 requests formulated at D0 (i.e. 0 day before the service day)

For realism, it then seemed necessary to take into account a fairly high cancellation rate. The cancellation phenomenon constitutes in fact the Achilles' heel of any route planning system. In a study carried out by the Toronto Wheel-Trans Service [1], the impact of this phenomenon is seen to be particularly serious - especially as a large number of cancellations occur on the day of service. In this study, a Transport Canada report [9] is cited in which the cancellation rate in Toronto is evaluated at 23%, and in Edmonton at 20%. Our analysis of operating reports for the handicapped transportation service of the Montreal Urban Community Transit Commission (M.U.C.T.C.) shows a cancellation rate varying between 18% and 23% for the first 4 months of 1984. In the absence of more detailed data, we made the following assumptions about the distribution of cancellations over the horizon period :

cancellations requests	formulated in D3	formulated in D2	formulated in D1	formulated in D0	Total
regular (410)	12	12	12	24	60
occasional formulated :					
in D3 (190)	5	5	15	25	50
in D2 (190)	-	5	10	30	45
in D1 (190)	-	-	5	25	30
in D0 (116)	-	-	-	6	6
					191

The cancellation rate generated in this way is slightly under 18%.

To simulate our working day, we used for the minibuses pieces of work similar to those used by the Wheel-Trans Service of Toronto. In Toronto, the minibuses are attached to 2 garages : the Crockford garage and the Gurney garage. A piece of work begins and ends at the same garage. We used the same format for pieces of work as that used in Toronto. However, we chose not to limit ourselves to the 60 pieces of work defined in Toronto for the 27th January 1983 so that our comparison of the different scenarios would not be affected by driver availability.

Note, finally, that a handling time is associated with each request to allow for embarkation and disembarkation of passengers. We also identified the minimum time, called the "taxi-time", necessary to transport a passenger from the origin to the destination. The evaluation of handling times, taxi-times and other trip times involved in this type of planning problem are discussed in [7].

4. The route construction procedure

Our route construction procedure involves the compilation of 2 main algorithms which we will identify henceforward as algorithms A and B.

Algorithm A has two functions : to construct a set of trips enabling a set of requests to be served, and to insert new requests into a set of existing routes with the possibility of initializing new routes if necessary. Algorithm B serves to reorganize and improve on the solution obtained through algorithm A.

Algorithm A is a heuristic based on a parallel insertion technique [2]. It is explained in detail in a C.D.T. publication [7]. This algorithm takes a set of known requests and simultaneously constructs routes for all vehicles starting at the beginning of the day and assigning requests to vehicles in small groups. Recent tests have shown that the solutions produced by the algorithm are significantly better in terms of productivity and service quality than those obtained manually in transportation firms who have supplied information [8].

Based on a set of routes which satisfy all requests, algorithm B improves the initial solution through optimization techiques. The algorithm has 4 main steps. The first step uses dynamic programming [5] to optimize each of the routes in the initial set provided. The second divides these routes into mini-clusters i.e. into sections so that the vehicle is empty only at the beginning and end of each of these mini-clusters. In the third step, integer linear programming with column generation [6] is used to reallocate mini-clusters between vehicles so as to minimize the number of vehicles and travel time. Finally, the fourth step consists of a reoptimization of each of the routes given by step 3 by proceeding in the same fashion as for step 1. This algorithm will be the focus of two forthcoming publications - one on step 1 [3] and one on step 3 [4]. Our study provided some of the first tests for this algorithm. The tests were conclusive : for example we succeeded in significantly improving on the solution provided by algorithm A for handling the 410 regular requests in our working day, reducing the total distance covered by about 15%.

5. The application of the procedure to scenarios 1 and 2

For the 2 first scenarios, route construction proceeds in 3 phases.

The first phase is common to both scenarios and involves the construction of routes to satisfy all regular requests. This phase can be carried out well in advance of the working day to be planned because it deals with requests which are known well in advance. Algorithm A is used to produce an initial solution which is then improved by algorithm B.

The second phase is carried out during the 3 days preceding the working day to be planned i.e. on days D3, D2 and D1. It is carried out differently according to whether a call-back policy is used (scenario 1) or not (scenario 2).

Scenario 1 (call-back) :

We proceed in three steps, each corresponding to the treatment of a batch of requests, and each generating a call-back task aimed at confirming the pickup time for the user.

Step 1 : requests formulated in periods D3 and D2 can be handled as soon as the D2 reservation period is over i.e. at 6:00 p.m. First, regular requests which have been cancelled during periods D3 and D2 are withdrawn from the routes previously constructed. Then algorithm A is used to insert occasional requests formulated (and not cancelled) in periods D3 and D2 and new trips are initialized if necessary. Algorithm B is then applied to consolidate the solution. This step gives rise to a call-back task which can be carried out on the morning of day D1.

Step 2 : this step begins at 1:30 p.m. on day D1. It involves handling requests and cancellations formulated in D1, before 1:30 p.m. The treatment is similar to that described for step 1 : withdrawal of new cancellations, insertion of new requests (initialization of new routes if necessary) by algorithm, and consolidation by algorithm. This step generates a call-back task which takes place in the afternoon of day D1. This task is much less voluminous than that generated in step 1.

Step 3 : after the end of the reservation period of D1 (6:00 p.m.) the requests and cancellations formulated after 1:30 are handled as in step 2. The call-back task generated is comparable to that generated in step 2 and is carried out early in the evening.

Scenario 2 (no call-back)

Each call received during periods D3, D2 and D1 immediately generates some kind of treatment. If the call is to cancel a request, this request is withdrawn from an existing route. If it is a new request, an attempt is made to insert it into an existing route using algorithm A. If this fails a new route is initialized. At the end of each day algorithm B is used to improve the routes constructed.

The third and final phase is carried out during day 0 in a similar way for both scenarios. Each call is immediately handled. If the call is a cancellation, the corresponding request is withdrawn from the route. If the call is a new request, an attempt is made to insert it into an existing route using algorithm A. If this is impossible, the request is refused as new trips cannot be initialized.

From the discussion above, it is clear that scenario 2 requires more real time work than scenario 1. Furthermore, the application of the procedure is complicated by the necessity in scenario 2 of confirming pickup times much earlier for occasional passengers calling on days D3, D2 and D1. In both scenarios, we have applied the same pickup confirmation policy for occasional requests as for regular requests, i.e. the -5, +10 policy. This means that when a pickup time is given to a user, the vehicle must arrive not more than 5 minutes earlier and not more than 10 minutes later than this time. The timing of pickup time confirmation influences the performance of our procedure because until a specific time has been given, more flexible time windows may be used to manipulate the request.

6. Analysis of results obtained for scenarios 1 and 2

Table 6.1 describes various statistics concerning the results obtained during the simulation of the working day for scenarios 1 and 2. The figures in the table show that route operating costs are higher with scenario 1. In fact, although the total travel time for scenario 1 is 1 hour 13 minutes greater then for scenario 2, scenario 2 requires 2 additional pieces of work (i.e. 21½ additional hours of wages) making it more costly. It should be remembered, however, that scenario 1 generates a call-back task which needs to be balanced against these costs. The policy of calling back all users reserving during periods D3, D2 and D1 generates 3 call-back tasks : 365 calls in the morning of D1, 89 calls in the afternoon of D1 and 99 calls in the evening of D1. At the end of this section, we discuss ways of reducing the size and cost of these tasks. Any cost analysis should also take into account the fact that scenario 2 requires the presence of a larger pool of receptionists who are capable of using the computer during phone-calls. In scenario 1, only same-day calls (requests or cancellations) need to be handled immediately, while in scenario 2, all calls (requests and cancellations) require immediate computer treatment. Given that our simulation can be taken as representative of any transportation system for the handicapped, and that any working day is at the same time a day of type D3, D2, D1 and D0 with respect of itself and following days, then we observe that scenario 1 generates 226 real time transactions per day (116 requests and 110 cancellations) while scenario 2 generates 877 (686 requests and 191 cancellations).

To analyze the productivity of the routes constructed by each scenario, we use 3 productivity ratios : driver productivity (DP), vehicle productivity (VP), and non-empty vehicle productivity (NP). These ratios are defined for each piece of work as follows :

$$DP = \frac{\text{number of passengers carried}}{\text{duration of the piece of work}}$$

$$VP = \frac{\text{number of passengers carried}}{\text{useful portion of the piece of work}}$$

where the useful portion of the piece of work is the sum of handling and vehicle movement times.

$$NP = \frac{\text{number of passengers carried}}{\text{productive portion of the piece of work}}$$

where the productive portion of the piece of work is the difference between the useful portion and the vehicle movement time without passengers.

Table 6.2 describes the observed distributions of the three productivity ratios for scenarios 1 and 2. Note that there is less regularity in the distribution generated for scenario 2 than that for scenario 1 where the central tendancies are more clearly marked. For this reason we prefer to use measures of position (median and quartiles) rather than averages to establish a comparison. Scenario 1 can thus be seen to be slightly better in terms of productivity than scenario 2.

In order to analyze the quality of service provided by each scenario, we focus mainly on the distribution of service delays and excess travel times across all requests. Service delays occur when there is some deviation from desired service times. If the request is for a specific departure time, the desired service time is a pickup time. If the request is for a specific arrival time, the desired service time is a delivery time. In our route construction procedure, all service time requests must be strictly satisfied. This means that no pickups occur before the desired pickup time, and no deliveries occur after the desired delivery time. All service delays are therefore positive and all users' needs are satisfied. Excess travel time is the time spent by a user in a minibus over and above the time which would be required to take him or her directly to his or her destination. Excess travel times can however be difficult to interpret. For example, an excess of 20 minutes might be satisfactory if the direct taxi-time were 30 minutes, but it would be highly unsatisfactory on a 5 minute trip. We therefore use a minibus-taxi ratio denoted by MTR to measure the excess travel time aspect of service quality. This ratio is defined as follows :

$$\text{MTR} = \frac{\text{total travel time in the minibus}}{\text{direct taxi travel time}}$$

Thus, the highest possible quality of service would be achieved with zero service delay, zero excess travel time and an MTR value of 1.

Table 6.3 shows the distribution of service delays, excess travel times and the ratio TMR for scenarios 1 and 2. We note very little difference in service quality between the two scenarios. For each variable, the means, medians and quartiles are very similar. Note also that the modes lie within the classes corresponding to the highest possible service quality and frequencies decrease for classes with poor service. In all cases, we note that for a small proportion of requests, service is of poor quality. This might be rectified by manual manipulation of the solution after each batch treatment of requests. We did not carry out such changes because we wanted to present the results as they emerged from our automatic procedure. In the application of the procedure, we allowed waiting time with passengers on board for the minibuses. These waiting times have little influence on service quality. They occurred only 22 times in scenario 1, and 20 times in scenario 2. Their average duration was 8.0 minutes in scenario 1 and 9.6 minutes in scenario 2, while their median durations were respectively 5.0 and 5.5 minutes. Spread over all requests, this produces an average in-vehicle waiting time per request of around 0.2 minutes. We also checked whether our policy of inserting occasional requests into trips constructed previously for regular request had an effect on the service quality produced initially by phase 1 of the route construction procedure for these regular requests. In neither of the two scenarios was there any significant change in the distributions of the three measures of service quality (i.e. service delays, excess travel time, and the TMR ratio). There are definitely some individual changes : for certain requests quality is reduced, but this is because quality is improved for other requests. Furthemore, regular users' habits are not affected unduly: small groups of regular users who habitually travel together are almost always maintained in practice*, although the order in which group members enter and leave the minibus may change. Our policy of inserting occasional requests into regular trips seems an efficient way of recovering losses in trip productivity generated by cancellations. The policy also allows improvements in the productivity of pieces of work taking place at non-peak hours of the day.

Our simulations of scenarios 1 and 2 also enable us to evaluate the ideal size of the minibuses to be used. To illustrate this type of information we show in Table 6.4 the distributions of the maximum number of passengers and the maximum number of wheelchairs carried by the minibuses in our system under each of the 2 scenarios.

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* there is no theoretical guarantee that this will occur, but it is what tends to emerge in practive because of the quasi-optimality of the initial routes.

It is important to note that the productivities and service qualities obtained in our 2 simulations are closely linked to our method of defining the time windows to be respected at each stop in our network, and throughout our procedure. A change in the initial time windows, or in the approach taken to tighten these after service times have been confirmed with users, will automatically affect productivity and service quality. In general, actions to increase productivity tend to reduce service quality and vice versa. In our procedure, we have tried to offer the same level of service to all types of users. But, this requirement could be changed. We might, for example, wish to provide better service to regular users than to occasional users. We could also operate so as to provide better service to occasional users the earlier they called in to formulate their requests. This might encourage occasional users to make requests earlier.

Without changing our procedure, we could define a call-back policy which would allow the costs of the call-back task to be reduced in scenario 1. This policy would involve immediately giving the occasional user calling in periods D3, D2 and D1 a pickup time chosen to correspond to optimal service quality. The user would be called back only if the planned pickup time calculated after a batch treatment of requests differed significantly (e.g. by more than 15 minutes) from the optimal pickup time. The calculation of optimal pickup time certainly requires some immediate treatment by the receptionist - but this is minimal :

$$\text{optimal pickup time} = \begin{cases} \text{departure time desired} & \text{if the request is for a departure time} \\ \text{arrival time desired} - \text{taxi time} - \text{handling time} & \text{if the request is for an arrival time} \end{cases}$$

Note that this policy can be described as one of 0, +15 similar to the -5, +10 policy explained in section 5. In the 2 cases, a confirmation generates a maximum waiting interval of 15 minutes for the user. Applied to scenario 1, this policy would reduce the three call-back tasks by 41%, 37% and 40% respectively. Even greater efficiency could be achieved by giving the user a probable pickup time based on statistical estimations of the mean deviation from optima pickup times for departure requests and arrival requests. Note, finally, if users knew at which times during day D1 their pickup times could be confirmed, a system might be envisaged in which it is the user who must call back. With such a system, problems caused by absent users could be avoided.

7. Conclusion

A comparison of the results obtained by simulating the same day's work under scenarios 1 and 2 leads to the following main conclusions :

(i) For similar service levels, productivity is only slightly lower under the non-call-back policy (scenario 2) than under the call-back policy (scenario 1).

(ii) Scenario 1 generates a heavy call-back task, while scenario 2 requires a greater number of real-time transactions on the computer.

To choose between the two scenarios, a transportation service for the handicapped must take into account its operating costs, its management priorities and the capacity of its personnel and its computer system to absorb a large volume of real-time transactions.

This work has also convinced us that we are on the right track in terms of developing an automatic procedure for route ans schedule construction which can improve on the manual or semi-automatic systems currently used by most services for the transportation of the handicapped. The procedure effectively handles the cancellation phenomenon, even taking advantage of it to deal with requests formulated on the service day. Our work has also enabled us to identify certain aspects of the procedure which need improvement, and has demonstrated our urgent need for more real data. We cannot now make detailed comparisons of the performance of our procedure versus current performance. The data bank used was incomplete, forcing us to complete it by simulating call times, cancellations etc.

In terms of future work, we intend to begin shortly an analysis of the scenarios in which taxis may be used. Already, an analysis of certain ratios leads us to observe that anticipated reductions in distances travelled because more than one passenger is carried at a time are negligible for certain routes. We intend also to deepen our understanding of how the definition of pieces of work affects productivity. A mechanism for producing reasonable work schedules for drivers must be included in our procedure. Using a similar format for pieces of work as that used in Toronto, we noted that an increase in productivity could cause problems in terms of the timing of lunch breaks for certain drivers. We also plan to study in more depth the impact on both productivity and service quality of the size of the pickup time intervals given to users.

Problem characteristics and route statistics	Scenario	
	1	2
Number of requests received	1096	1096
Number of requests cancelled	191	191
Number of requests accepted	894	895
Number of requests refused	11	10
Number of passengers transported	1019	1020
Number of pieces of work used	50	52
Number of vehicles used (1)	50	52
Total vehicle movement time	311h.07m.	308h.54m.
Total vehicle movement time without passengers (2)	84h.22m.	82h.23m.
Total handling time	74h.30m.	74h.40m.
Total duration of the pieces of work	594h.30m.	616h.

(1) In both scenarios this number could be reduced by 2 :

- at Crockford Garage, a vehicle could be used for a piece of work finishing at 15:00 and for another one starting at 18:00;
- at Gurney Garage, a vehicle could be used for a piece of work finishing at 14:30 and for another one starting at this same time.

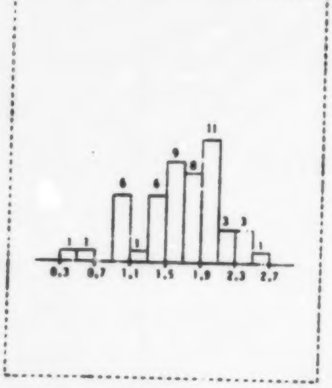
(2) Included in the total vehicle movement time.

Table 6.1

OBSERVED DISTRIBUTIONS OF THE DRIVER PRODUCTIVITY RATIOS

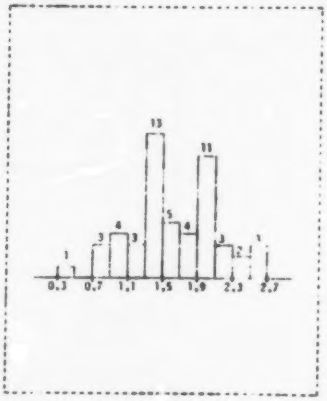
Scenario 1

N = 50
Mean = 1,69
Median = 1,77
Minimum = 0,44
Maximum = 2,67
1st Quartile = 1,44
3rd Quartile = 2,02
Std. deviation = 0,48



Scenario 2

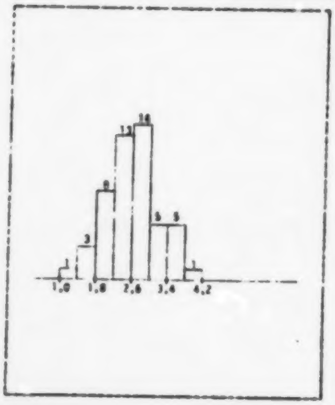
N = 52
Mean = 1,62
Median = 1,52
Minimum = 0,32
Maximum = 2,64
1st Quartile = 1,33
3rd Quartile = 2,00
Std. deviation = 0,51



OBSERVED DISTRIBUTIONS OF THE VEHICLE PRODUCTIVITY RATIOS

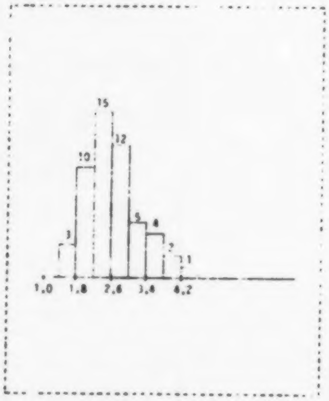
Scenario 1

N = 50
Mean = 2,61
Median = 2,60
Minimum = 1,32
Maximum = 3,96
1st Quartile = 2,22
3rd Quartile = 2,99
Std. deviation = 0,57



Scenario 2

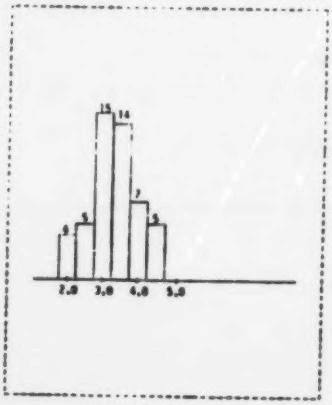
N = 52
Mean = 2,63
Median = 2,53
Minimum = 1,49
Maximum = 4,35
1st Quartile = 2,21
3rd Quartile = 2,92
Std. deviation = 0,61



OBSERVED DISTRIBUTIONS OF THE NON-EMPTY VEHICLE PRODUCTIVITY RATIOS

Scenario 1

N = 50
Mean = 3,36
Median = 3,37
Minimum = 1,99
Maximum = 4,58
1st Quartile = 2,97
3rd Quartile = 3,76
Std. deviation = 0,66



Scenario 2

N = 52
Mean = 3,41
Median = 3,20
Mimimum = 2,40
Maximum = 6,32
1st Quartile = 2,87
3rd Quartile = 3,75
Std. deviation = 0,80

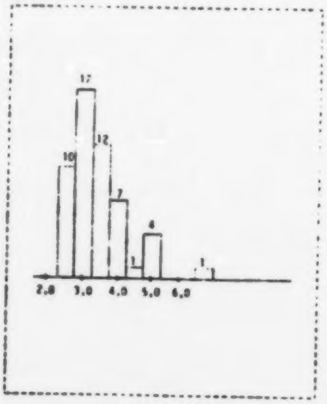
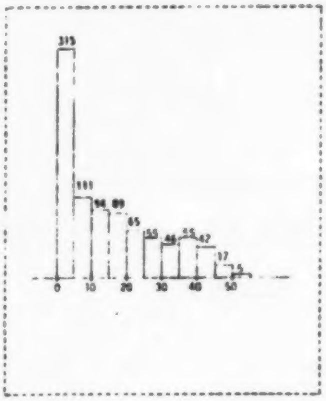


Table 6.2

OBSERVED DISTRIBUTIONS OF SERVICE DELAYS

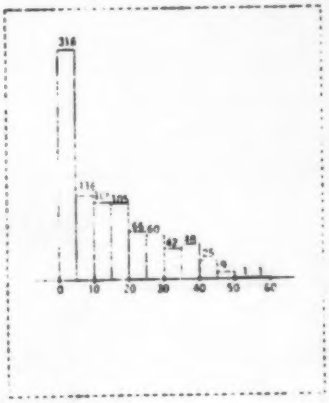
Scenario 1

N = 894
Mean = 14,78
Median = 11,00
Minimum = 0,00
Maximum = 53,00
1st Quartile = 3,00
3rd Quartile = 24,00
Std. deviation = 13,70



Scenario 2

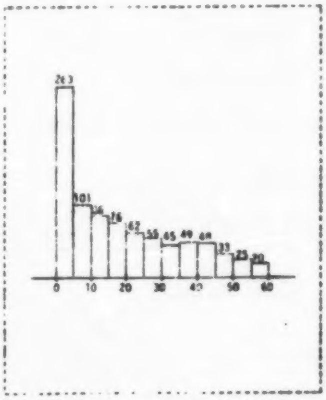
N = 895
Mean = 13,56
Median = 10,00
Minimum = 0,00
Maximum = 55,00
1st Quartile = 3,00
3rd Quartile = 21,00
Std. deviation = 12,57



OBSERVED DISTRIBUTIONS OF EXCESS TRAVEL TIMES

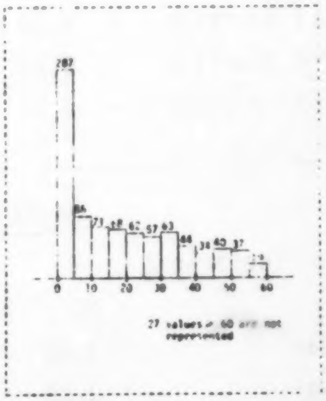
Scenario 1

N = 894
Mean = 19,44
Median = 14,00
Minimum = 0,00
Maximum = 80,00
1st Quartile = 3,00
3rd Quartile = 32,25
Std. deviation = 18,75



Scenario 2

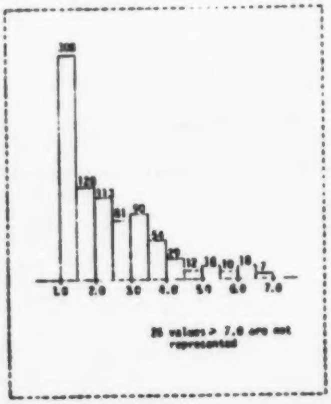
N = 895
Mean = 19,54
Median = 15,00
Minimum = 0,00
Maximum = 78,00
1st Quartile = 2,00
3rd Quartile = 33,00
Std. deviation = 18,88



OBSERVED DISTRIBUTIONS OF THE MINIBUS-TAXI RATIOS

Scenario 1

N = 894
Mean = 2,53
Median = 2,00
Minimum = 1,00
Maximum = 33,00
1st Quartile = 1,19
3rd Quartile = 3,12
Std. deviation = 2,05



Scenario 2

N = 895
Mean = 2,53
Median = 2,00
Mimimum = 1,00
Maximum = 20,00
1st Quartile = 1,13
3rd Quartile = 3,00
Std. deviation = 2,15

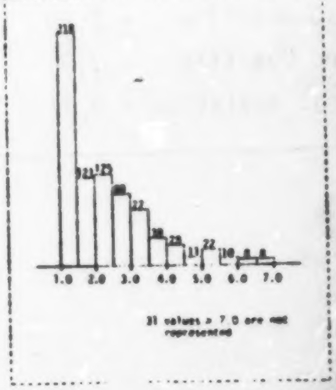
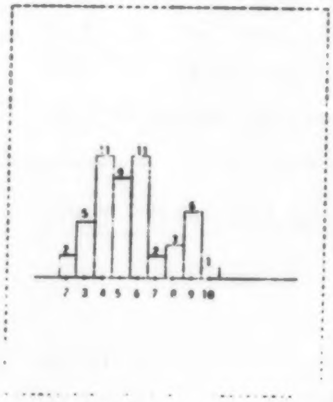


Table 6.3

OBSERVED DISTRIBUTIONS OF THE MAXIMUM NUMBER OF PASSENGERS

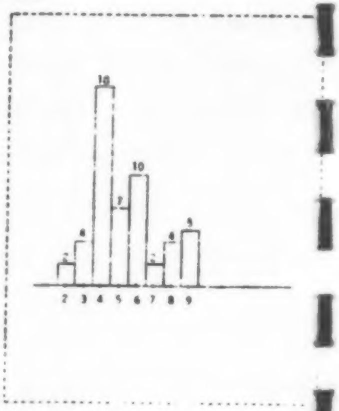
Scenario 1

N = 50
Mean = 5,52
Median = 5,00
Minimum = 2,00
Maximum = 10,00
1st Quartile = 4,00
3rd Quartile = 6,25
Std. deviation = 2,03



Scenario 2

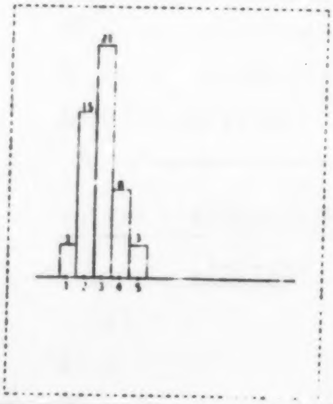
N = 52
Mean = 5,27
Median = 5,00
Minimum = 2,00
Maximum = 9,00
1st Quartile = 4,00
3rd Quartile = 6,00
Std. deviation = 1,89



OBSERVED DISTRIBUTIONS OF THE MAXIMUM NUMBER OF WHEELCHAIRS

Scenario 1

N = 50
Mean = 2,86
Median = 3,00
Minimum = 1,00
Maximum = 5,00
1st Quartile = 2,00
3rd Quartile = 3,00
Std. deviation = 0,97



Scenario 2

N = 52
Mean = 2,79
Median = 3,00
Minimum = 1,00
Maximum = 5,00
1st Quartile = 2,00
3rd Quartile = 2,00
Std. deviation = 1,00

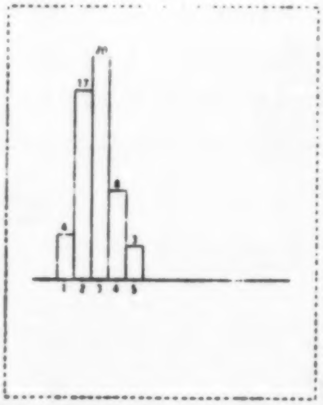


Table 6.4

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A CONJOINT ANALYSIS OF THE PREFERENCE FOR SERVICE BY HANDICAPPED PERSONS

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ABSTRACT

Proposed new regulations for handicapped persons in the United Stated mandate local service committments with wide options for service characteristics. These same proposals require equity between handicapped and nonhandicapped transit services.

To gain a deeper understanding of the tradeoffs that handicapped persons make between different service characteristics, responses to a conjoint questionnaire were analyzed for a sample of handicapped persons in a small urban area of the United States. Factors in the questionnaire were roundtrip cost, lead time for service and days and hours of service.

Utility functions were compared for different handicapped groups (those who were wheelchair confined, used wheelchairs had difficullty walking, had difficulty reaching and grasping, were sight or hearing impaired), and for preferences for work, shopping and recreational or social trips.

Concluding remarks related survey results to planning and policy decision-making.

A CONJOINT ANALYSIS OF THE PREFERENCE FOR SERVICE BY HANDICAPPED PERSONS

INTRODUCTION

The travel problems of handicapped individuals have been recognized since the Rehabilitation Act of 1973. In its newest proposed regulations, UMTA provides "minimum criteria for the provision of transportation services" for handicapped persons. These criteria provide for a mixture of accessible fixed-route or special services which are comparable to conventional services with respect to coverage area, days and hours of service, fares freedom from trip purpose restrictions and unreasonable waits. The precise definition of comparability is left to the local transit agency. This paper proposed that the consumers of these services—the handicapped people for whom these services are intended—be an integral part of the process by which they are designed. Further, since special and conventional services are by definition not exactly the same, it is proposed that the preferences and tradeoffs made by handicapped persons be used to determine comparability. The methodology includes the use of conjoint measurement of consumer preferences and is illustrated in a data set collected and analyzed for disabled residents of Greensboro, North Carolina.

Prior Studies of Travel Needs

A variety of studies have been completed which measure the travel needs and travel barriers of the transportation handicapped. These include studies by Michaels and Weiler (1974), ARI (1977), Grey Advertising (1978) and Benjamin and Sen (1982).

For the most part, these studies focus on the physical barriers to travel experienced by handicapped persons such as the inaccessibility of most facilities to wheelchairs. The Grey Advertising study was an ambitious study gathering data from a national sample. Preferences for service were included by both Michaels and Weiler and Benjamin and Sen. The latter took a market segmentation approach. One shortcoming of these studies was their assessment of attitudes towards transport attributes one at a time. The studies did not assess tradeoffs between specific levels of attributes and provided little guidance for the level of service provided once physical barriers are overcome.

Studies of Consumer Tradeoffs

To assess the tradeoffs made by consumers between product attributes have been developed for more than a decade. These consist of experimental methods in which subjects are asked to compare items systematically according to their preference. These techniques include tradeoff analysis, (Johnson, 1974) conjoint measurement (Green and Wind, 1973) information integration analysis (Anderson, 1976) and functional analysis (Meyer, et al) also known as direct utility assessment (Kocur, 1982). A thorough comparison of these techniques is presented by Benjamin and Sen (1982) and by Wind (1982).

In each of these techniques it is assumed that the choice between objects is made based on preference or utility for them. Object A is chosen over object B if the utility or object A is greater than the utility for object B. Furthermore, it is assumed that the utility for an object is a function for the partial utilities for the key characteristics of that object. This function may take any form, but is usually assumed to be polynomial or linear.

The use of conjoint techniques is not limited to evaluations of physical objects but maybe applied to services. In a study of proposed elderly and handicapped services in Xenia, Ohio, (Louviere and Kocur, 1979), a functional approach was used analyzing service attributes including transit fare, travel time, walk distance, type of service and headway. The study used a measure of the propensity to use a service as the dependant variable in a regression analysis procedure. The study illustrated the validity of the approach and demonstrated significant effects of socio-demographics on preferences for service. The study, however, lacked a specific emphasis on the transportation handicapped, the nature of their handicap and travel barriers they experience. The study reported in this paper adapts this procedure to a handicapped population.

STUDY BACKGROUND

Data for the study were collected as an additional part of a study of the transportation handicapped. This was a study of a market segmentation approach which considered both travel needs and travel barriers; the results of the study are summarized in a report by Benjamin and Sen (1982).

Sampling Frame

The total sample population for this survey consisted at 236 individuals. The sampling procedures combined four independent sample frames. Each frame represented an attempt to identify members of the handicapped population. Previous researchers had utilized similar sampling frames, but not in combination.

Each sample frame will be discussed in turn. An overview discussion follows the discussions of the four individual sample frames. A detailed analysis of each sample is available in Benjamin and Sen (1982).

The Random Sample

The random sample identified handicapped individuals by screening 5,000 respondents selected at random from the Greensboro telephone directory. Approximately 200 people indicated that they were eligible. A total of 54 interviews (22.9% of all responses) were completed using this sample method.

The random sampling procedures confirmed the finding of Grey Advertising (1978) that the handicapped population comprises approximately 4% of the urban population.

The Agency Sample

For this sampling procedure, public and private agencies serving elderly and handicapped clients were identified and the agency director or supervisor was contacted. Cooperating agencies were requested to provide a listing of potential survey respondents. All identified individuals were then contacted, screened for eligibility if necessary and, if eligible, asked to participate in the survey. Cooperating individuals were then interviewed. A total of 96 interviews (40.7%) were obtained using this sampling method.

The GATE Sample

GATE (Greensboro Area Transportation Express) is the principal service providing transportation to the elderly and handicapped in Greensboro. The GATE sample is classified separately from the agency above, due to its size and a different method of respondent identification. The GATE population comprised approximately 200 individuals over 18 years of age who rode GATE during the week of June 23-27, 1980. While GATE specializes in providng transportation services to the handicapped, the non-handicapped elderly also utilize GATE's services. Thus, identified GATE riders were first screened for eligibility and, when eligible, for willingness to participate. Individuals interested in participation were then interviewed. A total of 64 interviews (27.1% of all responses) were obtained through this sampling procedure.

The Self-Identified Sample

Respondents classified as self-identified fell into three classes:

1. Individuals suggested by other survey respondents or by project staff members;
2. Persons who learned of the survey through word of mouth or media coverage, contacted the research staff and requested participate; and
3. Persons "discovered" at an interview site where the original respondent had been identified in advance (by any of the other sampling methods).

The purpose of combining these different sampling procedures was to guarantee representation of groups that are only sparsely present in the population of an urban area. In particular, those people who were confined to wheelchairs were not represented at all in the random sample.

For the pooled sample, 73 percent indicated difficulty walking, 13 percent wheelchair confinement, 42 percent a visual impairment, 39 percent a tactile impairment and 28 percent a hearing impairment. The total of these percentages exceeds 100 percent because many respondents reported multiple handicaps and therefore the handicap categories are not mutually exclusive.

DATA ANALYSIS

Conjoint Questionnaire Design

The data analysis reported in this paper was of the conjoint questions. A key part of the analysis was construction of the questionnaire itself. Regardless of analytical approach, all conjoint techniques require a contrast between relevant atribute levels (or factor levels) in the different objects. This can be accomplished through the development of complete factorial design. In this design, the number of possible objects is equal to the product of the number of levels in each factor. The disadvantage of this approach is that even a small number of levels in a small number of factors leads to a large number of objects (e.g. three levels of three factors = 3 X 3 X 3 =27 possible different objects).

To avoid unreasonable tasks for subjects, especially those subjects who have disabilities, partial-factorial designs are used. These are carefully selected reduced sets of objects that provide all necessary balanced contrasts between factor levels. The most frequently used partial-factorial designs are orthogonal designs which permit assessment of part-utilities in linear models. A complete set of complementary orthogonal designs also provide sufficient data for analysis of interactions using a cross-sectional analysis. A more thorough discussion of partial-factorial experimental designs is presented by Benjamin and Sen (1982) and Kocur et al (1982).

The Study Questionnaire

The conjoint questions were an additional part of the market segmentation questionnaire. Since the major questions were quite lengthy, the conjoint questions were asked at the end as optional additional questions. As such only a subset of respondents answered the conjoint questions.

The questionnaire design was a Greco-Latin square (Weiner, 1971) which is an orthoganal design of factors with equal levels. Three factors at three levels each were used. The factors were round-trip fare, lead time (between when call for service is placed and when vehicle will arrive) and hours of availability of service. The levels of each factor are presented in Table 1. A complete set of the three complementary Greco-Latin squares was used for the study.

For this three-factor three-level problem there are 27 possible transit services that could be created. By using a Greco-Latin square, sufficient information was obtained from respondents that was comparable to the full-factorial design but only using nine possible transit services.

The services were presented randomly to each subject and the subject was asked to rate the service on an eleven point scale according to his estimate of how likely he was to use the service. Questions were asked separately for working or shopping trips (trips that are essential) and social or recreational trips (trips that are not essential). Subjects were presented with separately randomized services for each scenario. An example of a work/shopping questionnaire is presented in Figure 1.

Initial Results

A total of 236 subjects were interviewed as a result of the four different sampling techniques described in the sampling design section of this paper. Of these subjects, 108 completed the conjoint part of the questionnaire. Of these people, 15 were confined to wheelchairs, 19 used wheelchairs at least occasionally, 79 had difficulty walking, 47 had problems seeing, 24 had problems hearing and 44 had tactile problems (problems reaching and grasping). The typical respondent was a female, over the age of 60, was unemployed or was retired, had an annual income less than $5,000 and was not educated beyond high school. Approximately 55 percent of the sample was white.

Analysis of Preferences for All Groups

The analysis of preferences was a cross-sectional analysis and was completed using regression analysis to estimate part-utilities as coefficients in the following equation:

$$Y = B_0 + \sum_{i}\sum_{j} B_{i,j}X_{i,j}$$

where: B_o is a constant

$B_{i,j}$ is the part-utility of level j of factor i; i = 1,2,3 and j = 1,2,3

$X_{i,j}$ is a dummy variable representing the presence of level j of factor i in the service under consideration.

and Y is the indicated preference for the service under consideration.

Nine service evaluations were submitted to the regression analysis for each of the 108 respondents. Results of both the shopping scenario and social/recreational scenario are summarized in Table 1.

The relative importance of each factor for the range of levels presented to the respondent is indicated by the relative size of the range of part-utilities as well as the F statistic for each coefficient. Table 1 illustrates that round-trip fare was the most important factor for both shopping trips and social trips for the group overall. This is confirmed by both the relative range of the part-utilities and the F statistic for the trip-fare coefficients. Second most important is lead time. However, for social/recreational trips, lead time is not significant. For the overall group, time of availability is not significant, in fact it has a counterintuitive ranking for social/recreational trips. The R^2 values and F statistics are higher for shopping trips than social/recreational trips, although both F statistics are significant. Since this is a cross-sectional analysis, the last result indicates larger consistency of preferences for shopping trips than recreational trips. This inconsistency was an indication that other variables, such as type of disability or socio-demographic variables (the background of the respondents) could account for the variation in preferences.

Analysis of Background Variables

Dummy variable indicating socio-demographics as well as personal disabilities were entered in a stepwise regression after the factor-level variables. The step in which each variable was entered is listed in Table 2.

With the exception of age and education the most important predictors are all disability variables. This is true despite the fact that disability groups are not mutually exclusive. The most important disability was wheelchair confinement (entered in step 2). This result is reasonable because this disability is perhaps the most restrictive and it leads to the greatest dependance on assistance for travel. The socio-demographics age (step 1) and education (step 3) are also reasonable predictors since they are closely related to the level of travel activity of most people.

The importance of disability as a predictor of preference leads to the suggestion that groups of individuals who have similar disabilities also have similar service preferences.

Service Preferences for Disability Groups

Service preference part-utilities are listed in Table 3 along with function statistics for those confined wheelchairs and all other respondents.

The other respondents have similar preferences to those of the overall group discussed previously. However, when separated from the group, the wheelchair confined respondents demonstrated substantially different preferences.

For them, availability is the most important factor for shopping trips, fare second most important and lead time also has some bearing on service preference. This contrasts with preferences for recreational trips for which preferences are based on fare first and availability second. Here, there is a substantial difference in fare. The

The lowest fare (free) is less preferred than the next higher fare ($1.00). This is an indication that an ideal point exists for fare of service. An additional data set would be necessary to pinpoint the location of the ideal point.

This difference in preference is related to the need for the service. If the service is life-sustaining this disabled group is more willing to accept assistance but for non-essential trips they would prefer to pay as much as they can.

It should also be noted that the R^2 value is higher for the more homogeneous wheelchair user groups than it is for the population and the R^2 values for the other groups are approximately equal to that of the population.

Table 4 contains analyses for all disability groups for shopping trips. Aside from those confined to wheelchairs, each group finds fare most important, lead time second most important and availability of little importance. In each case free service is considered most preferrable. Only wheelchair confined people seem most concerned about availability.

This consistency is due in part to the overlap between groups but is also an indication of the difference in reliance on assistance of the different groups.

UTILIZATION OF PREFERENCE VALUES FOR SERVICE DESIGN

One way to define comparable services for consumers is to find services which have the same total utility. This found by summing the part-utilities for each level of each factor of the proposed service. Part-utilities for intermediate levels of a factors (between levels evaluated directly in the questionnaire) were estimated by interpolation.

Thus, if a service provided to the public has a fare of .50 (round-trip fare of \$1.00), is scheduled with a lead time of 30 minutes and is available from 6 am. to 10 p.m., the utility of an exact equivalent service for wheelchair confined persons is

$$U = U_1(\$1.00) + U_2(1/2 \text{ hour}) + U_3(6\text{-}10) = .30 + .17 + .00 = .47.$$

If, however, a dial-a-ride is suggested with the same utility but requiring a 24 hour lead time for calls, an equivalent service would require a compensatory improvement in some other service attribute. One way to estimate how much improvement compensates for the increased lead time is to reduce fare to a level that provides an equivalent total utility. By interpolation, the part-utility for a 40 cent round trip is .47. Total utility for a 40 cent service with 24 hour lead time available between 6 a.m. and 10 p.m. is thus 0.47 + 0.00 + 0.00 = .47 for which the total utility is exactly equivalent to the original service.

A fare reduction was not necessarily the only possibility. An expansion of service hours would compensate for the increased lead time. (Calculation of this is left to the reader.)

This approach redefines equivalent service based on overall service characteristics as perceived by the consumer. Instead of matching services for general and special populations attribute by attribute, this approach gives some additional flexibility by permitting tradeoffs between attributes to allow for the individual nature of special services.

CONCLUDING REMARKS

In this paper a method of assessing consumer preferences is applied to the problem of designing services for the disabled population. Because the sample is small, it is not suggested that these results are transferrable. However, the validity of the approach is demonstrated. The transferrability of these results will be confirmed by additional studies at other locations over time.

The most difficult element of the approach is the questionnaire design. The researcher should also be cautioned to the sensitivity of these questions to the effects of different sampling and questioning procedures. Extensive pre-tests with focus groups was of great assistance in this study.

The analysis presented in this paper is only one possible use of the conjoint data set. Another analytical approach to conjoint questions is to analyze responses for individuals respondents separately. Although cross-sectional analysis of individual responses leads to the same results as reported here, individual responses permit additional analyses that are helpful for planning. One example is that individual responses can be used to develop aposteriori service preference market segments. Another example of additional use of this data is to develop market simulations for proposed new services. These provide accurate forecasts of potential service utlization. A discussion of these approaches is presented in Benjamin and Sen (1982 a).

Finally, the use of results should be made in the context of reasonable service levels within existing financial constraints. The use of panels to confirm analytical findings is helpful as realistic constraints are applied.

This approach is one way to develop service guidelines as well as to define equivalent service. It is presented with the hope that in a time of financial restraint we do not lose sight of our goals.

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FIGURE 1. Example of Conjoint Part of Questionnaire

Part A - Work Trips or Shopping Trips

Personal Preferences

Questionnaire I.D. ☐ ☐ 2

Check one: ☐ **Work** ☐ **Shop**

	Round Trip Cost	Lead Time (Hours)	Time when Service is available	How Frequently You Might Use the Service										
				Never				Rarely		Half the Time			Usually	Always
1	**Free**	**On demand**	**6 a.m. - 10 p.m.**	1	2	3	4	5	6	7	8	9	10	11
2	**$4.00**	**On demand**	**24 hours a day**	1	2	3	4	5	6	7	8	9	10	11
3	**$1.00**	**On demand**	**8 a.m. - 5 p.m.**	1	2	3	4	5	6	7	8	9	10	11
4	**$4.00**	**2 hours**	**8 a.m. - 5 p.m.**	1	2	3	4	5	6	7	8	9	10	11
5	**$1.00**	**24 hours**	**24 hours a day**	1	2	3	4	5	6	7	8	9	10	11
6	**$4.00**	**24 hours**	**6 a.m. - 10 p.m.**	1	2	3	4	5	6	7	8	9	10	11
7	**Free**	**2 hours**	**24 hours a day**	1	2	3	4	5	6	7	8	9	10	11
8	**Free**	**24 hours**	**8 a.m. - 5 p.m.**	1	2	3	4	5	6	7	8	9	10	11
9	**$1.00**	**2 hours**	**6 a.m. - 10 p.m.**	1	2	3	4	5	6	7	8	9	10	11

Table 1

Service Preferences for All Groups

FACTOR	SHOPPING			SOCIAL/RECREATIONAL		
I. Round Trip Cost	Beta[1]	Std. Error(B)	F	Beta[1]	Std. Error(B)	F
1. Free	0.49	0.25	223.5[2]	0.05	0.50	1.8
2. $1.00	0.33	0.25	98.0[2]	0.27	0.50	49.2
3. $4.00	0.00	—	—	0.00	—	—
II. Lead Time						
1. On demand	0.27	0.25	66.0[2]	-0.05	0.50	2.0
2. 2 Hours	0.09	0.25	7.5[2]	-0.01	0.50	0.0
3. 24 Hours	0.00	—	—	0.00	—	—
III. Availability						
1. 8 a.m.-5 p.m.	-0.01	0.25	0.1	0.02	0.51	0.4
2. 6 a.m.-10 p.m.	0.00	—	—	0.00	—	—
3. 24 Hours	0.02	0.35	0.5	-0.00	0.7	0.0

Shopping		Social/Recreational	
Multiple R	= 0.50	Multiple R	= 0.26
Adjusted R^2	= 0.24	Adjusted R^2	= 0.06
F (6,927)	= 5.05[2]	F (6,848)	= 9.85[2]

---

[1] More positive coefficient indicates higher preference.

[2] Statistically significant at the .05 level.

Table 2

Socio-Demographics Entered for All Respondents*

Step	Variable
1.	Age
2.	Wheelchair Confined
3.	Education
4.	Difficulty Walking
5.	Hearing Problems
6.	Sight Problems
7.	Problems reaching and grasping
8.	Number of members in household
9.	Marital status
10.	Race
11.	Job Status

* All variable F statistics are significant at the 0.05 level.

Table 3

Service Preference for Wheelchair Confined People and All Other People

	Wheelchair Confined People		All Other People	
	Shopping	Recreational	Shopping	Recreational
I. FACTOR				
1. Free	0.50	0.18	0.49	0.04
2. $1.00	0.30	0.45	0.33	0.26
3. $4.00	0.00	0.00	0.00	0.00
II. Lead Time				
1. Free	0.19	−0.04	0.26	−0.06
2. 2 Hours	0.13	−0.08	0.07	−0.00
3. 24 Hours	0.00	0.00	0.00	0.00
III. Availability				
1. 8 a.m.-5 p.m.	−0.47	0.21	−0.00	0.01
2. 6 a.m.-10 p.m.	0.00	0.00	0.00	0.00
3. 24 Hours	0.42	0.07	0.02	−0.01
R^2	0.34	0.20	0.26	0.06
F statistic	0.8[1]	5.18[1]	28.8[1]	5.26[1]
degrees of freedom	(6,126)	(6,128)	(8,540)	(6,471)

[1] F statistic is significant at the .05 level

Table 4

Comparison of Preference for Shopping Trips by Handicap

FACTOR	All Subjects	Wheelchair Confined	Use Wheelchair	Difficulty Walking
I. Round Trip Cost				
1. Free	0.49	0.58	0.57	0.47
2. $1.00	0.33	0.30	0.34	0.32
3. $4.00	0.00	0.00	0.00	0.00
II. Lead Time				
1. On Demand	0.27	0.19	0.33	0.30
2. 2 Hours	0.04	0.13	0.19	0.12
3. 24 Hours	0.00	0.00	0.00	0.00
III. Availability				
1. 8 a.m.-5 p.m.	-0.01	-0.47	-0.04	-0.03
2. 6 a.m.-10 p.m.	0.00	0.00	0.00	0.00
3. 24 Hours	0.02	0.42	0.06	0.02
Numbers of subjects	108	15	19	79
R^2	0.24	0.34	0.33	0.24
F	50.5[1]	10.8[1]	13.29[1]	35.5[1]
degrees of freedom	(6,927)	(6,126)	(6,162)	(6,666)

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[1] F statistic is signifcant at the .05 level

Table 4 (Continued)

FACTOR	Sight Problems	Hearing Problems	Tactile Problems
I. Round Trip Cost			
1. Free	0.51	0.45	0.50
2. $1.00	0.33	0.29	0.33
3. $4.00	0.00	0.00	0.00
II. Lead Time			
1. On Demand	0.21	0.25	0.22
2. 2 Hours	0.07	0.10	0.12
3. 24 Hours	0.00	0.00	0.00
III. Availability			
1. 8 a.m.-5 p.m.	-0.02	-0.03	-0.05
2. 6 a.m.-10 p.m.	0.00	0.00	0.00
3. 24 Hours	0.01	0.02	-0.04
Number of subjects	47	24	44
R^2	0.24	0.21	0.23
F	20.5[1]	8.65[1]	18.67[1]
degrees of freedom	(6,399)	(6,201)	(6,369)

Evaluating the user benefits of special transport for the handicapped, elderly and disabled: experience from a study of Readibus, Reading, UK.

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1. INTRODUCTION: THE READIBUS SERVICE

This report summarises the results of research, undertaken to monitor the development of a special transport service for disabled and handicapped people, in Reading, Berkshire. The service began in October 1981, and the monitoring commenced in January 1982; the results reported here cover the period up to May, 1983.

The Reading service--Readibus--is a dial-a-ride system designed to improve travel opportunities for those who are immobile due to infirmity and disability of all types. The service operates under the terms of the Minibus Act (1977) and at present incorporates four Mercedes vehicles with tail-lifts and provision for carrying wheelchairs. Potential users can arrange a journey, up to one day ahead, by means of a telephone booking system: journeys may be for any purpose, and between any origins and/or destinations within Reading Borough.

Readibus is operated by the Reading Voluntary Services Council, and is funded predominantly by the Department of the Environment via Urban Aid: additional finance comes from Reading Borough, and in 1983 the service received further support via the Transport Supplementary Grant from the DOT.

The aim of the service at its inception was the provision "of an experimental scheme for the transport of disabled people within the Borough of Reading, for the individual purposes of the disabled." As noted, no journeys are excluded (with the exception of those services already offered by ambulances), the vehicles are painted in the same livery as Reading Transport buses, and trips may be made up to 11 P.M., seven days a week. Any individual experiencing difficulty in using normal services is eligible to use Readibus (including, where necessary, a companion). At the onset, fares were comparable to those on public transport, although these have since risen--to, for example, 55 pence for a return trip under one mile. *(Dollar equivalent $0.72).*

A secondary aim of the service was "to assess over the period of the scheme the impact of such a scheme on the lives of disabled people, and its potential as a model scheme for other areas." The research project reported here was one part of this assessment, and four goals were observed:

i. to identify and describe characteristics of users of the service, in order to show the structure of demand for such transport;

ii. to attempt an assessment of the benefits (however measured) that users of the service receive, in order to allow an assessment of the value of such a service to be made;

iii. to investigate the characteristics and travel requirements of those sections of the handicapped population in Reading who make little or no use of the service in order to show how effective such a service is in meeting the needs of the handicapped;

iv. to describe the main operational features of the service and identify the costs incurred in providing the service (both in total and on a journey-by-journey basis).

The remainder of this report is directed towards fleshing out these intentions, within the overall context of evaluating the Readibus service.

2. RESEARCH PROCEDURE

2.1. Data sources

This study employed several sets of data, although in the main these came from two basic sources. Our information on the operating characteristics of the service--notably cost data and passenger statistics--came from the staff of Readibus. Our data on individuals, whom we characterise below as "users" or "non-users," were collected by questionnaire methods. Most of the information came from surveys undertaken under our guidance, although both Reading Borough Housing Department and Berkshire County Council Social Services Department provided us with information collected under the guidance of their staff.

2.2. Passenger statistics

Data on the levels of demand for the Radibus Service are derived from analysis of the booking records: these are maintained by Readibus dispatch staff, and were filled out every time a trip was booked between October 20, 1981 and February 11, 1982. Thenceforth, increased demand made this level of detailed record-keeping impossible, and subsequent analysis is based upon data collected every third day for the months of April and August, 1982, and January and April, 1983.

2.3. Questionnaire studies

Our first detailed investigations of individuals were undertaken in May, 1982. The booking forms described above were used as a sampling frame, from which three groups of users of the service were identified. These were: frequent users; young disabled travellers; and others. All in all, seventy-four responses were used for data analysis: six of the eight frequent users were questioned, in addition to eleven of the fifteen riders aged under 40. The remaining 55 respondents were chosen randomly.

Our second study was undertaken in March, 1983 and focussed upon non-users. This study used as its sampling frame data collected by the RBC Housing Department during 1982; these related to over 1,000 elderly people living within the Borough. This data set yielded 75 respondents who had mobility difficulties, had heard of Readibus, but who had not used it. Our interviews were ultimately focussed upon 34 respondents.

In addition, we used a data set collected by Berkshire Social Services to yield information on younger, disabled people (i.e. those under 65 years of age). 23 individuals who were registered as disabled but had not used Readibus were contacted, and thirteen were ultimately interviewed. This portion of the research was also carried out in March and April, 1983.

The last interview set--i.e. that undertaken with the younger disabled--was unstructured, whereas the first two sets utilised questionnaires. In both the cases where individuals were contacted via local government organizations, initial contacts were undertaken by the latter, in order to maintain individual privacy where requested.

3. USE OF READIBUS

3.1. Demand for the Readibus service

Between October 1982 and September 1983, the total number of users increased to 1439: this represents approximately 35 new riders per month. Although demand has increased consistently, predictable fluctuations within the general trend remain: ridership is highest during the week and lowest at the weekend, and as may be expected, lower during the winter months.

3.2. Spatial distribution of trips

Approximately one quarter of trips are of journeys less than one mile; less than 5 percent are for distances in excess of four miles.

Consistent patterns of origin and destination have evolved, and these are shown in Figures 1 and 2. Large concentrations of users are noted in the West and Central parts of Reading. The major focus for trip destinations is the Central Business District; this notwithstanding, the other trips are well scattered throughout the town, both in terms of origins and destinations. This has major implications for aggregate ridership levels and journey times.

3.3. Trip purposes: booking record analysis

Table 1 indicates the range of purposes for which Readibus is used: (trips to and from home have been excluded). It can be seen that three trip categories account for approximately three-quarters of journeys made: these are 'social' (39%); shopping (24%); work (12%).

4. PROFILES OF USERS OF THE SERVICE

4.1. Trip behavior: questionnaire analysis

Table 2 indicates the purposes to which the Readibus Service was put and the relative importance of the service vis-a-vis other available modes. (Note that the data in this table relate to trip types, not trips: this measure condenses the information down to purposes, not frequencies of travel for the same reason). It can be seen that Readibus is only one of the mobility strategies employed by respondents: approximately one quarter possessed a household car, and one quarter had used a scheduled bus service within the preceding year. Readibus is however never used for less that 20 percent of journeys within any one trip type, and for one category--social visits--the percentage rises to over half. In summary, approximately one-third of both total journeys and total trip types employ the service. Most users employ Readibus approximately six to twenty times per month: only a minority makes more than twenty trips monthly.

4.2. User profiles

Approximately three-quarters of the users questioned were over sixty years of age; eight percent were over eighty years old. Many lived alone, and had low incomes; only 15 percent of respondents received more than £60 per week. Half the sample had neither a car nor the opportunity to arrange lifts with others. For this group, Readibus is a particularly important addition to their travel opportunities, and its members make approximately two-thirds of trip types using the service.

4.3. Evaluations of the service

Many respondents spoke favorably of the serice; even relatively long journey times were accepted and even enjoyed.

The system's booking service received far more criticism; users reported problems with gaining access; and irritation with the inability to book more than one day in advance.

Approximately one-third of respondents spoke of trips that they were unable to make: booking problems and destinations not served by Readibus were the primary reasons given. This latent demand reflected some perceived advantages vis-a-vis other modes, and these are summarised in Table 3. Readibus has few advantages over car travel, but as noted, many users do not have this option. Taxis are seen as expensive. Readibus has the attraction of individual assistance, although the booking system is a disadvantage; note however that positive assessments outweighed negative ones.

5. ATTITUDES OF NON-USERS

5.1. Latent demand and non-users

It was noted above that some respondents commented that there were a number of trips that they were unable to make. Similarly, studies undertaken by the local authorities indicated that there were potential users who were unaware of Readibus or were aware but had not used the service. We consequently investigated this non-usage.

Questionnaire analysis indicated three basic reasons amongst the elderly for non-use; approximately one-third had car availability; a group half that size had experienced some booking problems or had heard poor reports re. the service; and one-quarter was unaware of their eligibility to use the service. It should be emphasized that in the latter cases, a lack of knowledge represented also a basic lack of interest in travel: elderly males predominated here, in contrast to female counterparts.

Younger respondents provided essentially similar information. A larger group had adequate mobility, whilst a subsidiary number had encountered booking problems. Adequate mobility means, primarily, car ownership, and is associated naturally with higher incomes; some in this category were still in employment. For this group, mobility problems were typically caused at the smallest geographical scale: inadequate kerb ramps and poorly-designed buildings are a particular problem.

Typical booking problems included not possessing a 'phone, with consequent difficulties of liaison and communication, and disappointment when trying to book Readibus for important appointments more than one day in advance. Several respondents also pointed out that, despite problems presented by normal 'bus usage, the additional cost of Readibus (vis-a-vis a free bus pass) is prohibitive.

5.2. Latent demand and non-repeaters

An intermediate group--those who have not used Readibus more than three times--was also sampled, and 42 respondents interviewed.

Those sampled were in many ways similar to the user sample, although one-quarter could use a normal 'bus and half the group had access to a household car. Trip purposes were broadly comparable, but the key differential was the overall level of mobility: approximately half the sample had not left their home in the preceding week. Once more then, we found that low usage of Readibus represented either travel alternatives or low travel demand. In addition, approximately one-third of those contacted disliked Readibus, either due to the cost or the booking system.

6. COSTS, BENEFITS AND DISBENEFITS

6.1. Evaluation of operating characteristics

Analysis of data collected by Readibus staff for the period April-October 1982 indicates that during the rapid growth of the service, ridership and fare receipts remained constant. The ratio between driver hours and passengers carried was generally 1:2.1, and the mean fare receipt was approximately 34 pence. More recent figures indicate however that the number of trips per driver shift has risen between August 1982 and July 1983, from 11.7 to 16.5.

Data disaggregation was undertaken for the period of the last 10 weeks in 1982, and these figures are summarised in Table 4. Again, it can be seen that initial operational predictions have been bettered.

6.2. Financial data and trip costs

The most recent financial estimates available are for the period of the financial year 1982-3. Income and expenditure for the year are summarised in Table 5: it can be seen that a best estimate of £4.31 per trip is produced. This figure is a good deal lower than estimates produced for other dial-a-ride schemes: see Watts (1976) and Heraty (1983).

6.3. Quantitative and qualitative benefits of the service

Our detailed discussions with users of Readibus indicated that the service has had a noticeable impact upon their day-to-day existence in the majority of cases. We identified three distinct types of users, and this typology is summarised here.

Readibus has had least impact upon those households with a relatively high level of mobility, particularly those with a household car (group B). For this group, the service has simply been one additional potential travel mode, and use is correspondingly low. Users are generally critical of operational flexibility (particularly of the booking system) and do not depend upon the service to any degree. Readibus has had, overall, minimal impact upon travel behaviour, and would not be seriously missed if withdrawn.

In contrast, the service is well regarded by the elderly (group A). This group has increased its mobility as a result of the service, is dependent upon it and would greatly miss it if it disappeared. Because of this mobility improvement, riders in this category tend to be less critical of operational aspects, and emphasise instead its very real impacts upon the quality of their lives: several respondents spoke of the way in which the service had enabled them to act as individuals, increase their independence and reconstruct their lives--after years of immobility in some instances.

In relative terms, the third group (c) is also highly dependent upon Readibus, due to the status of its members as "high users." Three riders use the service for journey-to-work purposes and one utilises it for educational trips. These users clearly found the service useful for routine trips, although it is also significant that this is a small group which is being so serviced.

Group	Characteristics	Mobility	Readibus Use
Profile A			
Largest of user groups; least critical of service. Now very dependent upon Readibus.	Essentially elderly group; generally over 70 years, usually single females. Correspondingly low income. Disablement generally related to frailty and/or arthritis	Low: usually only 10 trips per month	Approx. 2/3 of trips, usually for social visits and shopping trips
Profile B			
Little latent travel demand; generally critical of operational aspects of Readibus	Younger group (20-50); more usually couples living in owned accommodation with household car. Some severely disabled.	high, over 20 trips per month. Wide variety of modes employed	Less than 15% of trips, usually for entertainment
Profile C			
Smallest group; highly dependent upon Readibus	Frequent users, of differing ages and with different trip purposes: employment, education, social visits. Some severely disabled.	Very high: 26-40 trips per month	Over 2/3 of trips by Readibus

It is difficult to submit the service to any precise quantitative scrutiny and to produce any cost-benefit data. In particular, data on changes in total expenditure on travel are not available. However, the service has improved mobility opportunities for many disabled people by increasing the number of trips made. On the one hand, there is little evidence that there has been a major redirection of expenditure from private cars and those with private vehicles still use them for the bulk of trips. On the other hand, over a quarter of Readibus trips represent a transfer from taxi travel--a proportion which was far higher (almost a half) for those with least mobility. This suggests that even given an increase in the number of trips made, their total travel expenditure will have declined.

In terms of savings or redirections of funds within the total welfare budget, it seems clear that Readibus is used for a high proportion of shopping trips, which in the past may have been undertaken by home helps, particularly for users in group A: this would not, however, tend to mean that the latter could be in any way dispensed with, as their role covers far more than this one task. In the longer term, it also seems likely that the service can function to allow some disabled persons to stay in employment or improve their educational qualifications. In both contexts, this could produce ultimate savings vis-a-vis welfare support, although it must be stressed that this group will always have restrictions placed upon it, due to the philosophy of the service which does not permit riders to book regular slots as required.

It is also possible that if people are able, through using Readibus, to keep up friendships and activity patterns formed before the onset of illness or old age, their demand for welfare support may be delayed. This may occur both because aid is provided by their friends who are kept in touch with their problems, and because the existence of the service is in itself an encouragement to maintain independent activities.

The qualitative aspects of the service are far easier to evaluate than its quantitative aspects. Riders are by definition customers whose satisfaction outweighs their dissatisfaction, and many respondents spoke warmly of the service, its impact on their lives and their preparedness to spend more upon fares if necessary. The ability of the service to lift feelings of stigmatisation and improve life quality is thus marked, particularly for elderly and frail persons.

6.4. Critical responses to the service

Non-users of the service can again be divided into three distinct groups, and profiles are presented in summary form below.

Group	Characteristics	Mobility	Readibus Attitudes
Profile D Largest of the groups: indifferent rather than critical: little latent demand.	A group from late middle-age through to elderly. Relatively high income, two person households	High household car ownership; trip levels highly variable, but generally made by car	Service offers nothing to this group that personal resources cannot provide
Profile E Little latent demand due to severe disability	Relatively elderly group, frequently with rapidly advancing disability	Deteriorating health has reduced latent demand for travel by any mode: less than four trip types per month	Service offers nothing to this group due to their immobility
Profile F Smallest group; critical of Readibus	A wider range of ages, some with greater personal independence; generally less disabled than those in Profile E or users of Profile A	Generally able to walk a little and/or use bus with difficulty. Trip levels variable but higher than amongst Profile E	Critical of booking procedure and fare costs

We can see that one of the groups (E) has little travel demand due to increasing disability. It could be argued that a more sophisticated service might permit even these individuals to make some trips, although it appeared clear that few respondents had any wish to regain their mobility. Group D in contrast is relatively mobile, but Readibus does not figure in the choice of travel opportunities. This group is similar to group B which also made major use of private transport. A further similarity lies in the generally higher incomes of many (though not all) in the group, which contributed to their lack of interest in the service. Group F is perhaps the most interesting of those identified here, insofar as it contained respondents who have latent travel demand which is not readily provided for by private vehicles or by Readibus. Respondents in this group were critical both of service attributes and fare levels, to the extent that they did not utilise the service. Instead, they used 'bus services, despite the problems that this entailed, or walked, despite the physical exertions involved.

It is clearly difficult to estimate quite how many potential riders fall into this category: our initial estimates suggest that in Reading it could be as high as 1000 elderly disabled persons (about 6 percent of pensioners in Reading) as well as an unknown number of non-elderly disabled. For these people, the service is not a satisfactory alternative even to the suboptimal modes of scheduled 'bus travel or walking. Respondents in this group were alienated by the booking procedures and inhibited by the fare structures.

6.5. Towards an overall assessment

We can summarise our results to this section in the simple table shown below.

Benefits	Disbenefits	
1. Employment for disabled 2. Employment for MSC* staff	1. High fares for riders 2. High subsidy per trip	QUANTITATIVE
1. Increased mobility, socialisation and personal wellbeing 2. Greater visibility of disablement problems	1. Dislike of booking procedures 2. Dislike of Readibus as 'bus, ambulance or 'charity'	QUALITATIVE

*Manpower Services Commission: Provides some drivers

This summarises our conclusions concerning the service. In terms of economic evaluations, we can argue that the service has allowed some disabled to stay in employment, and this figure will increase--although this may necessitate a rethinking of booking procedures. In a secondary context, the service has also provided a means whereby drivers and volunteers can be given useful employment. As far as qualitative benefits are concerned, many riders have benefitted enormously from an increase in mobility. Their sense of stigmatization has been reduced and their dependence reduced. In addition, it is important that the disabled are a visible group, whose problems are recognised by the majority population. The visibility of Readibus and its advertising campaigns have contributed to this process.

Any service is likely to have limitations, and Readibus is no exception. The attempt to balance costs and income is bound to be unsuccessful vis-a-vis some groups within the community. In this instance, the costs per trip (at £4.31) are somewhat lower than comparative serices; but this subsidy has been reduced at the expense of excluding some potential riders from the scheme. Throughout this study, it has been found that a basic problem facing many disabled persons is finance: the problems of old age, a single existence, and frailty can be minimised by personal wealth, or exacerbated by poverty, and some potential riders are unable to afford the current fares.

The booking system is a qualitative issue, but one nonetheless that has infuriated many users or would-be-users. From the outset, it has been the weak link in the organization of the service. The telephone system has been poorly designed for the consumer, insofar as it did not possess a queueing system or any recorded information to encourage the caller to stay on the line until the 'phone is answered. Although a queueing system has now been installed this would be much enhanced by a recorded message explaining the system but at present such a service is unobtainable. The inability to book regular journeys (e.g. for work or educational purposes) or to book more than one day ahead of time, means that important journeys (to connect with other transport modes, or to make an appointment) cannot be made reliably by this service. Further serious consideration needs to be given to the possibility of using one or two vehicles specifically for work trips at key times of the day. Furthermore, an attempt to structure other, flexible journeys around business, medical or transport deadlines could be made. An experiement with a limited number of advance bookings per day could be instituted to explore this possibility.

At present, the booking philosophy imposes its priorities over those of the passengers. It assumes that all trips have equal importance to riders, but this is clearly not the case. The disabled, as any ridership group, are capable of prioritising their trips, and our questionnaire study showed clearly that respondents did not mind taking circuitous routes if another passenger had a particular journey to make and if their own trip had a low personal priority. This area is one in which major improvements could be achieved relatively easily.

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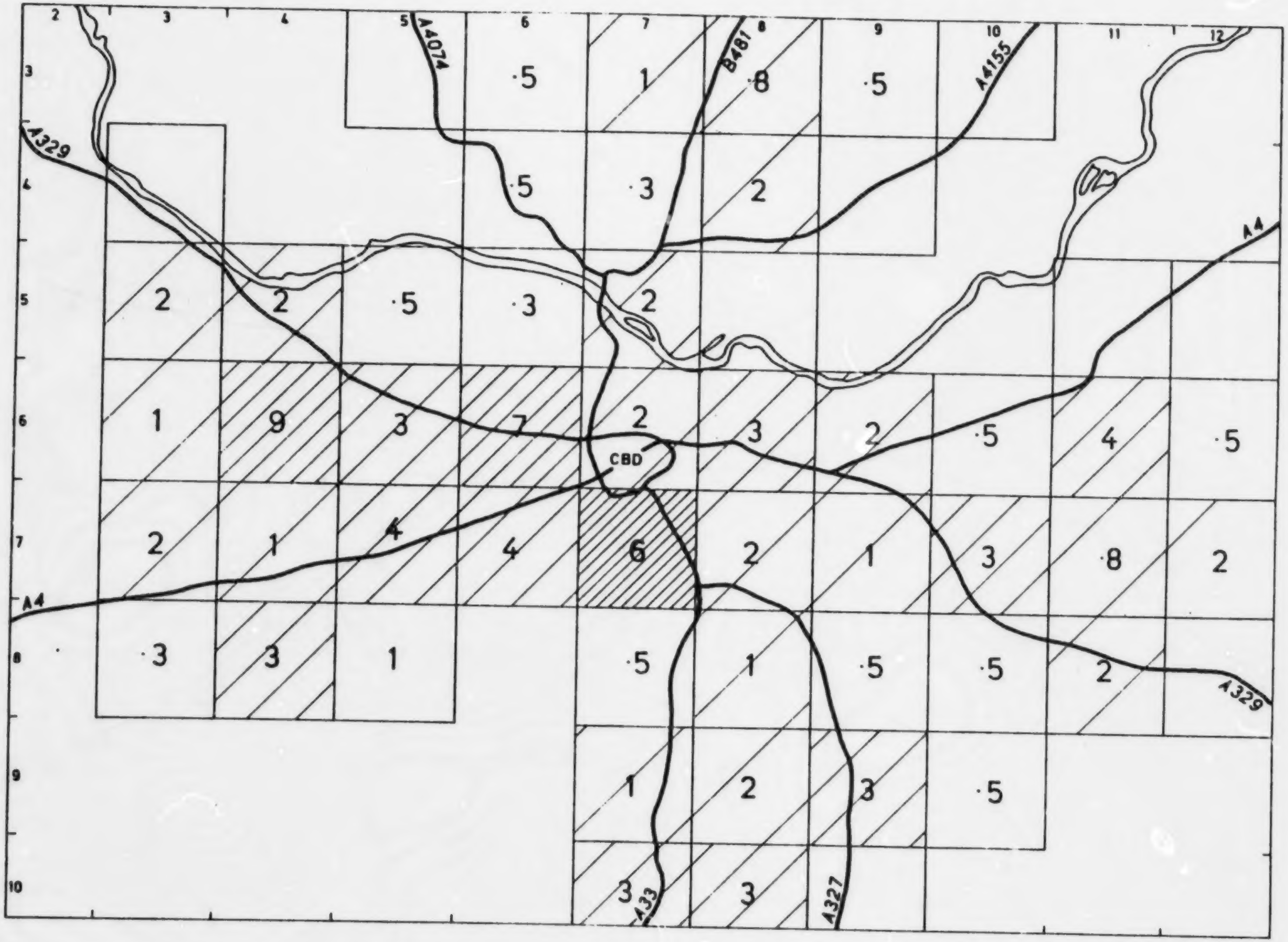
Figure 7 Distribution of users by percentage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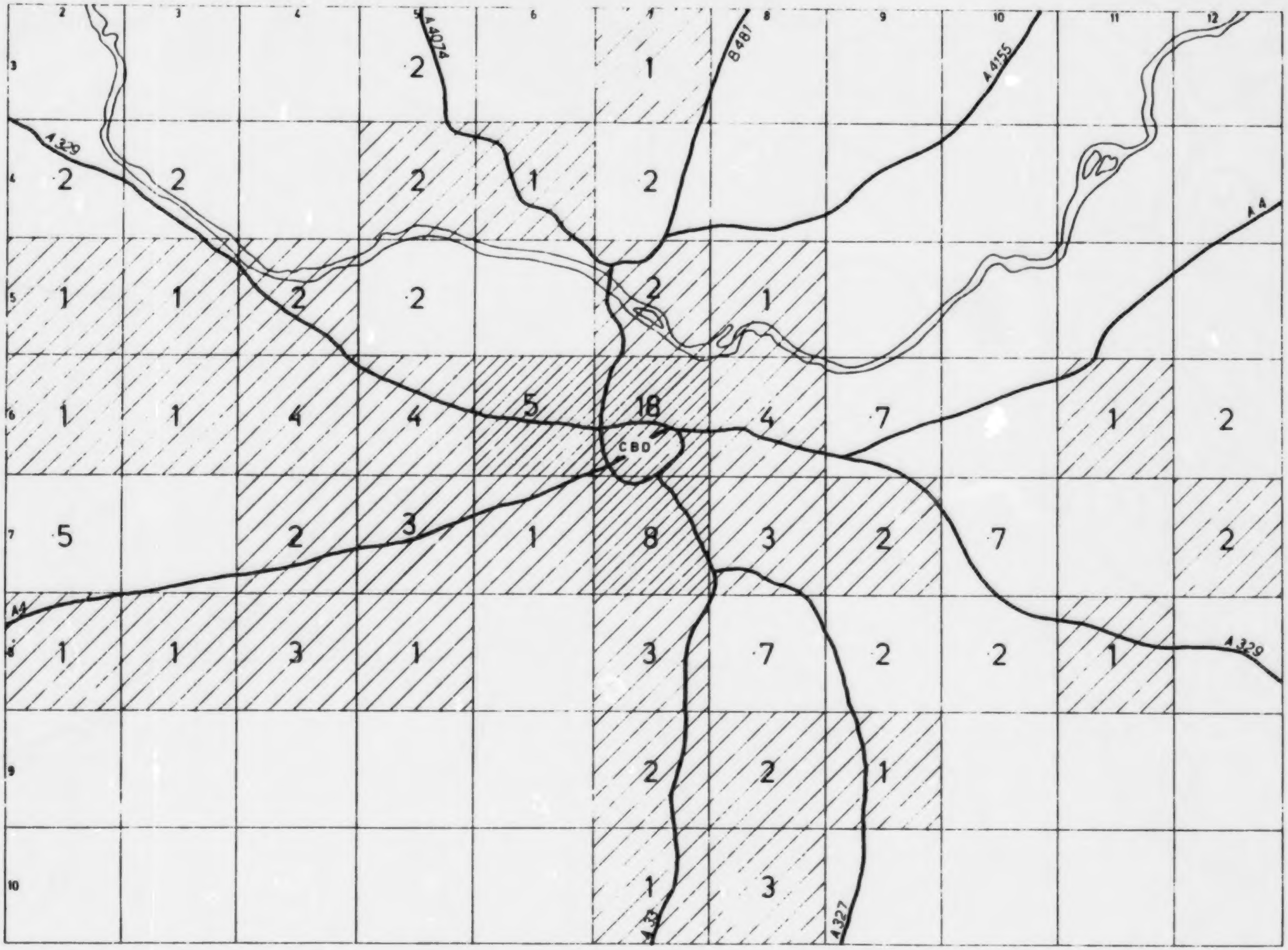
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Figure 2 Destinations of Trips. April 1983

Table 1 . Purposes of Readibus Trips excluding trips to or from home

	FROM		TO	
Purpose	No. of trips	% of trips	No. of trips	% of trips
Social	640	39	705	39
Entertainment/sport	66	4	68	4
Religious	19	1	38	2
Education	43	3	55	3
Personal Business	44	3	45	2
Shopping	391	24	421	23
Medical Appointments	138	8	168	9
Hospital visiting	101	6	106	6
Work	193	12	159	9
Intermediate mode	3	0.2	5	0.3
Other	14	0.8	19	1
Unknown	2	0.1	5	0.3
Total	1654	100%	1794	100%

Table 2 Trip purposes, Readibus and other modes[1]

Trip Purposes	As proportion of all Readibus trip types	As proportion of all trip types by all modes	Importance of Readibus (see 2)
Visiting friends/ relatives (and hospital visiting)	29%	19%	A
Shopping	18%	18%	C
Entertainment/ recreation	15%	17%	C
Medical	9%	12%	D
Personal business	9%	15%	D
Day centre/ disabled clubs	7%	9%	D
ordinary clubs	6%	4%	B
Clubs - indeterminate	2%	3%	D
work/education	6%	4%	B
Total trip types	100% (n=109)	100% (n=313)	

[1] Modes employed includes car and walking (see table 4.2)

2 A = more than 50% of this trip type by Readibus
B = more than 40%
C = more than 30%
D = more than 20%

Table 3 Advantages and Disadvantages of Readibus compared to other modes. No. of mentions.

Advantages	Advantages of Readibus relative to: Bus	Taxi	Car
None	1	3	26
Door-to-door service	24	5	3
Easy access	13	13	13
Cheaper	-	44	-
Less waiting	2	1	1
Staff helpful, caring	11	20	1
Comfortable	9	8	7
More reliable and flexible	1	5	9
Easier for wheelchair	1	4	2
More independence	1	3	4
Can go drinking	0	0	1
No response	-	-	2
Disadvantages	**Disadvantages of Readibus relative to: Bus**	**Taxi**	**Car**
None	28	46	56
Booking problems	4	8	3
Access problems	1	-	-
Not direct	-	1	1
Less reliable for appointments	-	1	1
Not as comfortable	-	-	1
No. of people using mode in last year	33	57	60
No. of people not using mode in last year	41	17	14

Table 4 . Key statistics on Operation; last 10 weeks of 1982

Shifts per week		Trips per week		Passengers per week		Fares per week (£)	
Max	Min	Max	Min	Max	Min	Max	Min
26	23	431	288	525	363	£160.25	£119.90

Trips per shift		Passengers per trip		Fares per shift (£)	
Max	Min	Max	Min	Max	Min
18.7	12.5	1.28	1.16	£6.16	£4.61

Trips per shift		Passengers per trip		Fares per shift (£)	
Mean	Predicted*	Mean	Predicted*	Mean	Predicted*
14.84	11.4	17.84	14.37	£5.46	£4.37

*Predictions made in January 1982, based on operational data in November 1981

Table 5 . Estimate of costs per trip: financial year 1982/83, including estimates for vehicle and computer costs.

Item	Cost in £'s	% of costs (rounded to nearest whole number)
Employees	52662	61
Premises	35	0
Establishment	5653	7
Transport	17362	20
Vehicle depreciation*	8480	10
Computer depreciation**	2667	3
Total	86859	
Less Revenue	6890	
Total	79969	
Trips in year	18548	
Costs per trip	£4.31	

* Based on capital costs of 42,400 over five years

** Based on capital costs of 8,000 over three years

THE MOBILITY OF THE HANDICAPPED
IN THE FEDERAL REPUBLIC OF GERMANY

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A COMPARATIVE EVALUATION OF THE MOBILITY HANDICAPPED IN THE FEDERAL REPUBLIC OF GERMANY

ABSTRACT

Until recently the study of the handicapped has been impeded by the lack of data in many countries. A major study in the Federal Republic of Germany, however, has made possible an assessment, not only of the extent to which the handicapped are represented in the population, but also an accurate knowledge of the proportion of these people who are mobility handicapped.

A meaningful evaluation of the degree to which a mobility handicapped person is disadvantaged, however, can only be made if the situation of other persons of similar socio-demographic characteristics is known. This paper, therefore, uses the data on the mobility of the handicapped and combines it with data from a comparable survey of the travel behaviour of the whole population to provide a control group. Using this technique it is possible to identify very significant differences in mobility between the control group and the mobility-handicapped persons.

In general, the mobility handicapped leave the house less often than their non-handicapped counterparts, but when they do leave home they (need to) carry out more activities. They also spend longer travelling and correspondingly less time at their destinations. The "mode" most frequently used by the mobility handicapped is walk, although public transport plays a dominant role for the mobile mobility-handicapped person when compared with a person from the control group. The paper provides the basis for further research and policy making in this area.

A COMPARATIVE EVAULATION OF THE MOBILITY HANDICAPPED IN THE FEDERAL REPUBLIC OF GERMANY

1. INTRODUCTION

An assessment of the mobility (or immobility) of those persons who may be classified as mobility handicapped has been hindered until recently by the absence of data on the subject. In general, there has been relatively little knowledge on the extent to which mobility-handicapped persons are represented in society. This lack of information has meant that a comparison of the situation of these people with the rest of the population has been virtually impossible.

In 1981, however, three Federal ministries in the Federal Republic of Germany commissioned a project to determine the number and status of disabled persons in that country. The study, and some of its initial findings are described in Brög and Ribbeck (1). In particular, it was possible to distinguish those persons among the handicapped who were handicapped in their mobility in some way. The study showed that 6.98 million German persons over 18 years of age were handicapped. (This did not include persons living in insititutions.) Of these, 5.29 million persons, or 11.9% of the total population could be classified as mobility handicapped.

An analysis restricted only to mobility handicapped persons, however, does not allow satisfactory conclusions to be drawn about the nature and range of activities which can no longer be fully or partially realised as a result of the handicap. In addition, since the socio-demographic structure of the handicapped differs substantially from that of the population at large (1), and since this socio-demographic structure significantly influences the patterns of out-of-house activities, such comparisons are not sufficient to report on the relevant mobility deficits of these persons.

The problem was solved in this case by selecting a group of control persons who were not handicapped. Data on the mobility of these persons were available from another German national survey on travel behaviour (KONTIV 82) which coincided with the handicapped survey. Comparable persons were selected so that they represented as exactly as possible the socio-demographic structure of the mobility-handicapped group. This method was chosen because it had already been successfully applied in a pilot study of this project in which the mobility of those who lived at home and needed nursing was studied (2).

Using the above framework, this paper presents a comparative evaluation of the mobility handicapped by analysing the (out-of-house) mobility characteristics of the control persons, the mobility handicapped, and the whole population. The analysis is based on indicators derived from the ability to leave the house at all (share of mobiles), the daily frequency of leaving home (number of sojourns), the activity programme of the mobiles (trips/sojourns, out-of-house activities, mode used, etc.), the time spent at each out-of-house activity and the time needed to reach them.

2. THE MOBILITY HANDICAPPED

In order to gain a better understanding of the current definition of mobility handicap, the five categories of mobility-handicapped persons are described in brief (Table 1). The theoretically immobile (I) constitute the smallest percentage (5.2%) of these persons. The second category (11.6%) is made up of these persons who are theoretically dependent on other people and mechanical aids such as crutches or walking sticks (P+M). Then, there are two further groups which theoretically "only" need to be accompanied by another person (P) (24.8%), or "only" need the assistance of a mechanical aid (M) (13.5%). Finally, there is the group which "only" has difficulty with structural impediments (S) such as steps (44.9%). All these groups are "theoretical" in the sense that, under extenuating circumstances, mobility is sometimes observed from the immobile persons, while all the other groups are forced occasionally to make trips without the aids on which they depend.

3. MOBILITY INDICATORS

On an average weekday 60% of the mobility handicapped leave the house at least once. This value is approximately 25% less than for the non-mobility handicapped although, as the corresponding value from the control group shows, most of this difference is attributable to the different socio-demographic characteristics, and only a small part to the mobility handicap itself (Table 2).

If the house is left at all, in every second case this is not limited to one sojourn (i.e. home - other destination/s - home); each mobile mobility-handicapped person makes 1.53 sojourns per day. This value is higher than that for the control group and almost as high as that for the remainder of the population. Since leaving the house presents a mobility barrier for nearly all handicapped persons, it can be concluded that under favourable conditions (e.g. the availability of an accompanying persons, momentary good physical condition, etc.), people will attempt to develop the most comprehensive activity programme possible. At least one reason for this is to compensate for the deficits when the favourable conditions are not available. Relative to all persons, the number of sojourns still lies well below the comparable values (Table 2).

This tendency is reflected also in a comparison of trip frequencies. Here it can be seen that the number of trips per person is lowest for the mobility handicapped, but that when they become mobile they take part in more activities than the control persons. This finding is confirmed, even if not as strongly, by the number of trips per sojourn. In view of the relationships just discussed, the number of activities outside the house is not surprising. For the mobile mobility-handicapped persons it is higher than for the control group, while overall for the mobility handicapped it is lower.

Shopping trips (which are necessary to obtain basic supplies)once again clearly show the necessity for the mobility handicapped to organise their (rare) out-of-house mobility carefully. Each time they are mobile they carry out 0.83 shopping activities — a value which is not only above that of the control group but also well above that for the non-mobility handicapped. This is, however, just sufficient to give all 3 groups a fairly constant "base shopping level" of 0.5 trips per persons per day. Similar results can be seen for recreational activities even though the control group is slightly lower (Table 2).

The average duration of a trip is only just 10% higher for the control persons than for the non-mobility handicapped. (This is also related to the discussion on mode use below). Once again, this value is slightly surpassed by the mobility handicapped with the relatively high average travel time of 1¼ hours per mobile mobility handicapped. In contrast, these people spend much less time at each activity. This means that mobility-handicapped persons need longer to reach their out-of-house destinations but actually spend less time at these activities. Both effects can be related to the handicap itself. (Table 3). By combining the travel time and the duration of the out-of-house activities, an out-of-house time of 4 hours 40 minutes per mobile mobility-handicapped person can be calculated. This value is 3/4 hour higher for the control persons. This difference can be explained entirely by the varying times spent at the destinations.

For all mobility-handicapped persons, including those who were not mobile on the sample day, therefore, the time spent at home is more than 21 hours per day -- just under 1 hour is spent travelling and almost 2 hours are spent at the activities themselves. For both comparison groups the time spent at home is significantly lower. The time spent per person at shopping or recreational activities is almost identical for all 3 group; the corresponding travel times are only slightly different. This means that mobility-handicapped persons take part in travel activities hardly any less than comparable non-mobility handicapped persons (Table 3).

Expressed in trip-frequency, mobility is produced by activities which are or have to be undertaken outside the home. The disaggregation of trips according to the activities at the destination confirms the results to date on the structure of these out-of-house activities. Shopping and other supply-type trips are at the top of the list for both the mobility handicapped and the control persons, closely followed by trips which make recreational activities possible. The frequency of other trip purposes is related to socio-demographic structures which are discussed in detail in another analysis (1). Service trips -- i.e. trips in which another person is accompanied -- not surprisingly, appear most frequently among the non-mobility handicapped. Nevertheless, even this purpose is a component of the activities of the mobility handicapped -- though less frequently. This is an indicator that in households where several mobility-handicapped persons live, those who are "less handicapped" are called upon to accompany the more severely handicapped (Table 4).

When all persons are considered, there are similar frequencies for shopping trips for all three groups. The somewhat smaller percentage of this type of trip by the non-mobility handicapped is particularly noteworthy because it represents the same number of shopping trips. It appears that it is relatively simple to include shopping into a more complex trip chain.

Despite having the lowest overall mobility, the mobility handicapped make the highest number of recreational trips per person per day. On average, seven out of eight mobility-handicapped persons make one recreational trip per day (Table 4).

4. MODE USE

When the main mode used for travel is considered, the "mode" walk clearly heads the list for the mobility handicapped. This dominance is primarily at the expense of car driver. In addition, car passenger trips among the mobility handicapped are comparatively more frequent both in cars owned by the household and in other cars. Public transport is also used more frequently by the mobility handicapped -- twice as often as by the non-mobility handicapped. Very much oversimplified, this means that the relationship between the 3 groups for travel as a car driver is 4:3:2 (non-mobility handicapped:control group:mobility handicapped) which has to be compensated by the reverse relation (2:3:4) for walk and public transport trips. In contrast, the relatively high proportion of bicycle trips by the mobility handicapped is surprising -- with 6% hardly less than the control group -- while the more frequent use of taxis is easily explained. (Table 5).

Almost every mobility-handicapped person shows an average of one walk trip per day -- a value which, despite an overall mobility which is more than 30% lower, is a good third above the corresponding value for the non-mobility handicapped. It confirmed the effects already noted in the pilot study which showed that the mode walk was the absolutely dominant mode for the mobility handicapped. This was followed by car driver and public transport trips, the former comprising just under half the frequency of walk trips and the latter about one third. The higher percentage of passengers leads to a relatively high car occupancy of those vehicles used by the mobility handciapped (Table 5).

A division of the main modes according to trip purpose or activity type leads to conclusions which go beyond the previous results but show no noteable differences between the 3 groups. Walk trips generally dominate for recreational and, particularly, shopping activities, while car trips are most important for business trips and car passenger trips for recreational trips. In comparison, public transport is used fairly equally for all activities with a small peak for shopping travel. The level of car occupancy reflects the generally well known picture. It is highest for recreational trips and lowest for work trips. The significant differences in mobility between the three groups are adequately identified, therefore, by the central indicators (Table 6).

As already noted, average trip duration is highest for the mobility handicapped (Section 3). This is related mainly to the (somewhat) longer duration of walk and public transport trips. Both effects are related to the persons' mobility handicaps. Trip durations for passengers are longer when they are associated with a car which does not belong to the households, quite possibly because this type of arrangement is made mainly for relatively longer trips. In contrast, the passenger trips made in a household car are significantly shorter. This form of transport is frequently necessary even for shorter trips made by the mobility handicapped; this trend is even more significant for trips by taxi (Table 7).

From a socio-political perspective the use of public transport by the (mobility) handicapped is of central interest. In this respect it is necessary to differentiate between how many persons use public transport at all on average day, what is the share of public transport (as the main mode) as a percentage of all trips, and, since with urban public transport more than one mode per trip is frequent, what is the share of public transport compared with all other modes for all travel? The results indicate that every fourth mobility-handicapped person who is mobile makes at least one trip with an urban public transport mode. This value is significantly above comparable values -- 20% for the control groups and 15% for the non-mobility handicapped. Through the frequent use of several public transport modes for one trip (on average 1.35 public transport modes per trip), public transport provides a 22% share of all modes used by the mobility handicapped. The corresponding value for the control persons is just over 25% less and for the non-mobility handicapped is more than 50% less with values of 16% and 10% respectively. When all persons are considered these differences are not as marked (due to the lower trip frequency of the mobility handicapped) but public transport still retains a much greater importance for the mobility handicapped than for the other two groups (Table 8).

Of all the modes used for these trips, bus is of particular importance. It is used most frequently both in total and in combination with other modes. The reason is twofold: the absence of other fixed track modes in many areas, and the important feeder function of buses even where there are fixed track modes (Table 8).

5. MOBILITY BY DAY OF WEEK

One of the significant findings of the pilot study (in which the mobility of those who lived at home and needed nursing was studied) was the evidence that the mobility of this group varied between weekdays and weekends. The reason was the heavy reliance of these people on nurses and persons who cared for them. To anticipate the results of the section which follows, in the main study, when all the mobility handicapped were considered, this finding was not supported.

As could be expected, the overall mobility of all 3 groups is less on the weekend -- both the total time out-of-house and the time spent at actual out-of-houe activities. The only difference appears in the travel times. The generally longer trip durations on the weekends for both the non-mobility handicapped and the control persons is not found for the mobility handicapped. This means that their overall travel time is also significantly lower. Obviously the mobility handicapped prefer to avoid longer stays in traffic if they are not absolutely necessary. (Table 9).

In contrast, the trip purposes for all 3 groups follow the same pattern; work trips are limited, rather naturally, to weekdays, while the dominant trip purpose on the weekends is recreational activity (Table 10).

The main mode used varies significantly by day of week but offers no further clue to other differences between the three groups; walk, and more particularly passenger, trips increase on weekends, while public transport and car driver trips decrease (Table 11).

An examination of the day of week dimension, therefore, adds little to the dimensions which were shown to differentiate between the three groups in Sections 3 and 4 of this paper.

6. SUMMARY

The analysis of the mobility of the mobility handicapped compared with a control group of persons with similar sociodemographic characteristics, and with the total population showed that the major areas in which the mobility handicapped have problems over and above those persons similar to them who are not handicapped, falls into two major categories.

The first relates to mobility itself. A smaller percentage of mobility-handicapped persons travel at all, compared with the control group and the total population. When they do leave home, however, they do so more often than the control group, and carry out more activities. In general, it takes mobility-handicapped persons longer to reach a destination and they stay at that destination a shorter time than their control persons, and the mobility handicapped spend longest at home.

The second general characteristic which clearly differentiates the mobility handicapped from the control group relates to the mode used to reach out-of-house activities. The predominance of walk trips for the mobility handicapped is a recurring theme, and when the mobility handicapped are mobile they are also much more likely to use public transport than either their control group or the population as a whole.

A third category -- mobility by day of wekk -- was examined but shown to have only weak influence.

The foregoing analysis, by identifying various areas in which the mobility handicapped could be seen to be disadvantaged, has highlighted areas where policies could be effectively implemented to change the existing situation.

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Table 1

GERMAN MOBILITY HANDICAPPED
(18 years & over)

MOBILITY HANDICAPPED IN THE CATEGORY:		Total %	Absolute (Rounded) Millions
I	(Theoretically Immobile)	5,2	0,28
P+M	(Theoretically dependent on Other People and Mechanical Aids)	11,6	0,61
P	(Theoretically "only" dependent on Other People)	24,8	1,31
M	(Theoretically "only" dependent on Mechanical Aids)	13,5	0,71
S	("Only" difficulties with Structural Impediments)	44,9	2,38
TOTAL		100,0	5,29

Table 2

GERMAN PERSONS 18 YEARS & OVER

CHARACTERISTICS - OUT-OF-HOUSE ACTIVITIES	All Persons			Mobile Persons		
	Total (Not Mobility Handicapped)	Comparable Persons	Mobility Handicapped	Total (Not Mobility Handicapped)	Comparable Persons	Mobility Handicapped
Share of Mobiles	75,8%	66,5%	60,4%	-	-	-
Out-of-House Activities	1,68	1,22	1,16	2,21	1,84	1,91
- Work	0,42	0,19	0,09	0,55	0,29	0,15
- Shopping	0,49	0,50	0,50	0,64	0,75	0,82
- Recreation	0,50	0,41	0,50	0,66	0,62	0,83
- Other	0,27	0,12	0,07	0,36	0,18	0,11
Sojourns	1,20	1,00	0,92	1,58	1,50	1,53
Trips	2,87	2,22	2,08	3,79	3,34	3,44
Trips per Sojourn	-	-	-	2,40	2,23	2,25

GERMAN PERSONS 18 YEARS & OVER

Table 3

CHARACTERISTICS **TIME BUDGETS**	All Persons			Mobile Persons		
	Total (Not Mobility Handicapped)	Comparable Persons	Mobility Handicapped	Total (Not Mobility Handicapped)	Comparable Persons	Mobility Handicapped
Duration per Trip*)	-	-	-	23,9	26,1	26,3
Duration of Travel*)	69	58	55	91	87	91
Duration per Activity*)	-	-	-	152	129	99
Time Out-of-House*)	323	216	169	427	324	280
Time at home	18h 36'	20h 24'	21h 11'	16h 53'	18h 36'	19h 20'
Time for Out-of-House Activities	4h 15'	2h 38'	1h 54'	5h 36'	3h 57'	3h 9'
- Work	2h 15'	1h 6'	31'	2h 58'	1h 39'	51'
- Shopping	26'	28'	28'	34'	43'	47'
- Recreation	1h 2'	52'	51'	1h 22'	1h 18'	1h 24'
- Other	32'	12'	4'	42'	17'	7'
Time Travelling	1h 9'	58'	55'	1h 31'	1h 27'	1h 31'

*) in Minutes

Table 4

GERMAN PERSONS 18 YEARS & OVER

TRIPS to
OUT-OF-HOUSE ACTIVITIES

	All Persons			Mobile Persons		
	Total (Not Mobility Handicapped) - absolute -	Comparable Persons - absolute -	Mobility Handicapped - absolute -	Total (Not Mobility Handicapped) %	Comparable Persons %	Mobility Handicapped %
Work	0,99	0,50	0,23	34	22	11
Education	0,11	0,02	0,01	4	1	0*)
Shopping	0,82	0,93	0,91	28	42	44
Recreation	0,76	0,67	0,87	27	30	42
Service	0,07	0,04	0,02	3	2	1
Other	0,12	0,06	0,04	4	3	2
TOTAL	2,87	2,22	2,08	100	100	100

*) Less than 0.5%

GERMAN PERSONS 18 YEARS & OVER

Table 5

MAIN MODE OF TRAVEL	All Persons			Mobile Persons		
	Total (Not Mobility Handicapped) - absolute -	Comparable Persons - absolute -	Mobility Handicapped - absolute -	Total (Not Mobility Handicapped) %	Comparable Persons %	Mobility Handicapped %
Walk	0,69	0,79	0,94	24	36	45
Bicycle	0,24	0,16	0,12	9	7	6
Motorised Bicycle	0,05	0,02	0,01	2	1	0
Car Driver	1,30	0,71	0,40	45	32	19
Car Passenger (Household car)	0,17	0,12	0,14	6	6	7
Car Passenger (Other car)	0,09	0,06	0,08	3	3	4
Transit	0,23	0,28	0,33	8	12	16
Taxi	0,01	0,01	0,02	0	0	1
Train	0,04	0,03	0,02	1	1	1
Other	0,05	0,04	0,02	2	2	1
TOTAL	2,87	2,22	2,08	100	100	100
Car Occupancy				1,20	1,26	1,54

Table 6

GERMAN PERSONS 18 YEARS & OVER

MAIN MODE USED BY ACTIVITY TYPE	Total (not mobility handicapped)				Comparable Persons				Mobility Handicapped			
	Work	Shopping	Recreation	Other	Work	Shopping	Recreation	Other	Work	Shopping	Recreation	Other
	%	%	%	%	%	%	%	%	%	%	%	%
Walk	12	36	30	17	13	47	41	18	25	52	46	18
Car Driver	61	33	37	50	60	19	25	54	45	13	16	50
Car Passenger	5	8	16	6	5	6	14	7	4	5	18	7
Transit	9	9	5	9	10	16	10	7	17	19	13	16
Other	13	14	12	18	12	12	10	14	9	11	7	9
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100
Car Occupancy	1,09	1,25	1,43	1,13	1,09	1,32	1,58	1,13	1,09	1,41	2,15	1,14

Table 7

GERMAN PERSONS 18 YEARS & OVER

DURATION by MODE and TRIP

	Total (not mobility handicapped) -Minutes-	Comparable Persons -Minutes-	Mobility Handicapped -Minutes
Walk	19,4	22,0	22,4
Bicycle	17,5	18,7	20,6
Motorised Bicycle	18,2	17,5	10,8
Car Driver	21,7	23,3	22,1
Car Passenger (Household car)	26,4	28,7	23,9
Car Passenger (Other car)	23,3	23,7	24,2
Transit	39,4	38,4	40,1
Taxi	21,5	22,4	14,0
Train	92,3	116,0	111,7
Other	56,2	71,2	46,0
TOTAL	23,9	26,1	26,3

Table 8

GERMAN PERSONS 18 YEARS & OVER

TRANSIT USE	Total (not mobility handicapped)		Comparable Persons		Mobility Handicapped	
	%		%		%	
All Persons						
- Transit Users per day	12		13		15	
- Transit as Main Mode	6		8		10	
- All transit used	8		10		13	
Mobile Persons						
- Transit Users per day	15		20		25	
- Transit as Main Mode	8		13		16	
- All transit used	10		16		22	
Transit Distribution (in %)	Main Mode	All	Main Mode	All	Main Mode	All
- Bus	56	76	55	73	51	82
- Tram	21	25	25	29	35	36
- U-Bahn/Train (Urban)	12	15	12	15	10	12
- S-Bahn	11	12	9	9	4	5
Average number of transit modes used per transit trip	1,28		1,26		1,35	

GERMAN PERSONS 18 YEARS & OVER

Table 9

CHARACTERISTICS BY WEEKDAY and WEEKEND	Total (not mobility handicapped)			Comparable Persons			Mobility Handicapped		
	Total	Weekdays	Weekends	Total	Weekdays	Weekends	Total	Weekdays	Weekends
Share of Mobiles	75,8%	78,7%	68,6%	66,5%	69,1%	59,8%	60,4%	63,5%	55,6%
Trips/Person	2,78	3,10	2,33	2,22	2,40	1,84	2,08	2,28	1,78
Trips/Mobile	3,79	3,94	3,39	3,34	3,47	3,08	3,44	3,58	3,20
Duration /Trip*)	23,9	22,6	27,9	26,1	24,7	29,5	26,3	27,8	23,4
Travel Time/Person*)	69	70	65	58	59	54	55	63	42
Travel Time/Mobile*)	91	89	95	87	86	91	91	99	75
Time Out-of-House/Person*)	323	364	219	216	238	161	169	201	120
Time Out-of-House/Mobile*)	427	462	319	324	344	270	280	316	217
Times per Person									
- Time at Home	18h 36'	17h 57'	20h 21'	20h 24'	20h 3'	21h 20'	21h 11'	20h 39'	21h 59'
- Time at Destinations	4h 15'	4h 53'	2h 34'	2h 38'	2h 58'	1h 47'	1h 54'	2h 18'	1h 19'
- Time Travelling	1h 9'	1h 10'	1h 5'	58'	59'	54'	55'	1h 3'	42'

*) Minutes

Table 10

GERMAN PERSONS 18 YEARS & OVER

TRIPS to
OUT-OF-HOUSE ACTIVITIES

	Total (not mobility handicapped)		Comparable Persons		Mobility Handicapped	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
	%	%	%	%	%	%
Work	41	13	27	8	15	3
Shopping	29	26	45	32	49	35
Recreation	18	56	22	57	32	61
Other	12	5	6	3	4	1
TOTAL	100	100	100	100	100	100

GERMAN PERSONS 18 YEARS & OVER

Table 11

MAIN MODE OF TRAVEL	Total (not mobility handicapped)		Comparable Persons		Mobility Handicapped	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
	%	%	%	%	%	%
Walk	24	25	35	38	44	47
Car Driver	46	43	33	30	20	18
Car Passenger	7	16	6	15	9	14
Transit	9	5	14	8	18	12
Other	14	11	12	9	9	9
TOTAL	100	100	100	100	100	100
Car Occupancy	1,16	1,36	1,20	1,49	1,44	1,76

ECOSOMETRICS INCORPORATED

COST ANALYSIS TECHNIQUES FOR TRANSPORTATION SYSTEMS SERVING THE ELDERLY

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ABSTRACT

High-quality cost accounting and analysis techniques are seldom in evidence in the management of transportation systems serving the elderly and handicapped. With reduced budgets for social services in the U.S., and a much greater emphasis on cost-effectiveness and program performance, the need for cost analysis methods that are useful for the service provider has become greater and greater. This paper describes research funded by the Administration on Aging of the U.S. Department of Health and Human Services that addresses this void.

From in-depth interviews with all service providers in 16 randomly selected planning and service areas across the United States, costs were recorded on a micro level for the resources used in the delivery of services to the elderly. These detailed cost components allowed the development of parametric cost equations that express overall costs of service while controlling for factors such as degree of urbanization in the service area, level of service, service quality, and other factors.

The study resulted in a research report plus a cost analysis manual for Area Agencies on Aging local service providers to use in measuring or constructing their true costs of service delivery. The manual outlines a complete cost analysis, including all cost categories required, and provides typical ranges of costs for certain kinds of operations. This paper describes the uses of the manual, and provides some details about the cost categories and ranges of costs actually observed in the field.

COST ANALYSIS TECHNIQUES FOR TRANSPORTATION SYSTEMS SERVING THE ELDERLY

The transportation problems of older Americans have been the focus of a great deal of attention over the past decade, but not all subtopics have been thoroughly covered. We studied cost analysis techniques because previous research demonstrated a fundamental lack of knowledge concerning the costs of services provided to the elderly. Indeed, not only were specific dollar costs unknown, but basic cost analysis principles were not being followed. The problems observed in the literature included:

- service costs were compared from different years without standardizing to a base year,
- cost comparisons were often based on varying definitions of service,
- measures of units of service were inconsistent,
- it was often unclear which costs were included,
- there was no standardization of quality of service, and
- the comparisons often combined and confused costs of production and costs of consumption.

Initial interests in fairly straightforward questions -- What are the costs of services for the elderly? and What are the cost differences between serving the rural and urban elderly? -- thus led to a broader and more useful investigation.

A research project funded by the Administration on Aging[1] led to the development of a standardized methodology for determining the costs of services for the elderly. This methodology corrected the deficiences noted above. It provides a resource-based approach which assigns dollar values to all inputs required to deliver services, whether or not such expenses are included in an agency's budget or in their list of expenditures. Adopting this more comprehensive approach would obviously involve a change in thinking for many agencies. If this hurdle can be surmounted, the benefits for better decision-making are substantial: local providers can get a clearer picture of their true costs, factors that vary from region to region or site to site can be better understood, and standards for comparisons to other systems can be developed. All these factors lead to more informed management decisions about service attributes and to greater cost-effectiveness. Specific instructions for applying this methodology are presented in a cost analysis manual, a companion volume to this report.

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[1] Mark C. Wozny, Sue F. Knapp, Jon E. Burkhardt, et al., The Cost of Services to the Elderly: A Resource-Based Approach to Cost Analysis, prepared by the Institute for Economic and Social Measurements, Inc. for the Administration on Aging and the Institute for Social Research of the University of Michigan under Grant No. 90-A-1279.

In this study, the services costed in detail are transportation and in-home services. These two services are vital to older Americans and they have been recognized as priority services by the Administration on Aging. Transportation services provided to the elderly by agencies contacted for this study are generally provided separately from other transportation services by human service organizations. Among the 49 transportation providers studied, the average elderly transportation system has three vehicles and provides most of its service on an advance reservation basis. Door-to-door service is common. For the 56 in-home service providers studied, the services most often provided are personal care, homemaker services, and nursing care, using personnel of various skill levels, depending on the service. Federal funds account for nearly 60 percent of the annual income of both the transportation and in-home providers.

The comprehensive cost analysis framework examines human service costs in terms of three dimensions: the service being costed in terms of requisite activities and functions, the resources necessary to provide the service, and the costs of the resources. This approach develops service costs in terms of the actual amount of resources needed to deliver a service unit and the costs of those resources as determined by a particular setting. Because this approach works by combining very detailed individual cost elements, called parameters, the overall costing methodology is known as "parametric cost modeling." It can be used to estimate the unit cost of a service using simple equations. The beauty of this methodology is that, while they are simple, the equations include all costs of the service. The basic parametric cost model developed for this study is:

$$\begin{matrix}\text{TOTAL}\\ \text{SERVICE}\\ \text{COSTS}\end{matrix} = \left[\left(\begin{matrix}\text{Service}\\ \text{Operating}\\ \text{Costs}\end{matrix}\right) + \left(\begin{matrix}\text{Service}\\ \text{Administrative}\\ \text{Costs}\end{matrix}\right) + \begin{matrix}\text{Service}\\ \text{Capital}\\ \text{Costs}\end{matrix}\right]\left(\begin{matrix}\text{Agency}\\ \text{Administrative}\\ \text{Expense Factor}\end{matrix}\right)$$

The total cost of a particular service is calculated by estimating the service operating costs (e.g., wages for persons providing nursing services) and adding to them the cost of administering that service (e.g., wages for supervising the nurses). The capital costs attributable to that service (e.g., vehicles for transporting clients) are then added in. This subtotal represents all program costs associated with that particular service. The general agency administrative factor, which represents that portion of the agency's total administrative costs that should be allocated to that one service program (sometimes known as the agency's indirect or overhead rate), is then multiplied by the program costs to arrive at a total cost. Both program and general agency administrative costs are expressed as ratios (decimal equivalents) of the administrative costs to operating or program costs.

This study recorded or estimated values for all of the resources used to produce a service, whether those resources were paid, donated, or volunteered. The calculation of total resource costs is not influenced at all by the extent to which these costs are offset by program income, grants, contributions, or other income-generating sources. After a total cost analysis is performed, a comprehensive financial plan can be drawn up showing how the costs will be covered. Funding considerations are thus subsequent to, and beyond the scope of, the work described here.

DATA BASE AND METHODOLOGY

The first phase of this work involved an extensive review of the literature on costs of transportation and in-home services. In the second phase, data were collected by a review of documents and cost accounts plus very detailed interviews with 110 service providers in 16 Planning and Service Areas (PSAs)[1] around the country. The 16 PSAs were selected by the University of Michigan to be representative of the 256 PSAs in the U.S. where both transportation and in-home services were offered to the elderly by service providers who were receiving some Title III funds.[1] In order to observe the effects of various factors on the costs of services, sampling controls were provided for four U.S. Census regions, four levels of urbanization, the size of the PSA, and the organizational framework of the Area Agency on Aging in each PSA.

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[1] A PSA is a geographic service area designated under Title III of the Older Americans Act of 1965, as amended. Almost 680 PSAs now exist. Within each PSA, services to the elderly are administered and coordinated by an Area Agency on Aging.

The study team first contacted the Area Agency on Aging in each of the 16 PSAs in order to obtain a complete list of service providers. Personal contacts were then made with all service providers in each of the 16 PSAs who had some Title III funding to provide transportation or in-home services. In-depth interviews were conducted in the offices of the service providers with executive directors or program administrators. These interviews ranged from one to three hours in length, and involved inspections of accounting ledgers, enumerations of space and equipment, and verifications of various rates and costs. The completed data collection instrument resulting from each contact thus contained extremely detailed reports and observations on personnel and their activities, space, equipment, and administrative procedures. Since the interviews were performed in 1983, the data collected represent 1982 fiscal year costs and performance figures. Highlights of selected findings are summarized below.

FINDINGS

Transportation Costs

The sample of 54 transportation providers produced 65 completed data collection instruments about transportation services to the elderly. The 65 data instruments described services obtained in three different ways: 49 agencies directly provided transportation services (that is, they ran their own transportation operations); nine purchased services from other providers; and seven agencies reimbursed their staff or agency volunteers for providing services with their own vehicles. Nine agencies obtained services in more than one way. The detailed cost analyses were performed only for those 49 agencies providing transportation directly.

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[1] The information source for identifying the 256 PSAs which met these criteria was the 1981 National Data Base on Aging Survey conducted by the National Association of State Units on Aging and the National Association of Area Agencies on Aging.

Although the 49 transportation agencies were alike in purpose and mode (that is, a general mixture of fixed route and demand-responsive services), they differed substantially on other characteristics. Table 1 provides a sense of the basic dimensions of these systems for use as benchmarks against which to measure other systems. In addition to those characteristics of the provider agencies shown in Table 1, six percent of the agencies (3 providers) charged for their services and the remainder did not. Of those who did not charge, 45 percent (21) had a suggested contribution and the remainder of that group did not.

Table 1

CHARACTERISTICS OF TRANSPORTATION SYSTEMS
SERVING THE ELDERLY

(Base: 49 agencies directly providing services)

Characteristics	Mean	Median	Standard Deviation
Trips per Month	2,725	1,881	3,131
Number of Vehicles	5.8	3	6.1
Vehicle Miles per Month	6,667	4,092	6,419
Hours of Service per Week	37	40	10.6
Vehicle Hours of Service per Month	963	480	1192.3

In order to understand transportation costs, it is necessary to differentiate between costs to make a mile of transportation service *available* to clients (*production costs*: costs per mile, per hour) from costs to supply those trips actually *taken* by elderly clients (consumption costs: that is, costs per trip). The obvious link between the two is how many trips are actually taken for each mile of service provided (expressed as the total number of trips taken by all clients served during a month divided by the total number of miles driven by all the vehicles of the systems during that month.)

Three transportation production rates were considered in the study: 1) trips per vehicle mile, 2) trips per hour of vehicle availability and 3) miles per hour of vehicle availability. Trips per mile averaged .437, while trips per available vehicle hour and miles per available vehicle hour average 3.88 and 9.80 respectively.

As expected, trips per vehicle mile are greater in urban areas than in rural areas (31.1% greater, at .379 in rural areas and .497 in urban areas). The trips per available vehicle hour are 41 percent greater in urban areas, and miles per available vehicle hour are 26 percent greater in urban areas.

There is a strong relationship between urban/rural and the cost per mile and trips per mile (significant at the .01 level) -- the more urban an area the greater their cost per mile and trips per mile. There is a less strong relationship between the cost per trip and the urban/rural nature of an area (although still statistically significant at a 10% confidence level) -- the more urban an area the greater the cost per trip.

Even controlling for service quality, there is a strong relationship between urban/rural and cost per mile, with the cost per mile for both high and low quality services considerably higher in urban areas. The findings are more mixed with regard to cost per trip. For high quality services, the cost per mile is significantly greater in urban areas. However, for low quality services, the difference between the cost per trip in urban areas and rural areas is not significant.

The most important measure of service costs is cost per trip since this measures the costs of each unit of transportation service actually consumed by an elderly client. From previous research it was suspected that, if quality[1] were taken into account, the cost per trip would be higher in rural areas or at least comparable to the cost per trip in urban areas. The data from this study show some urban/rural differences in cost per trip among providers of different qualities of transportation service, although none were statistically significant. For low quality services, the cost per trip is 12 percent higher in rural areas. For high quality services, the cost per trip is 51 percent higher in urban areas. Overall, the cost per trip is 14 percent higher in urban areas. Table 2 presents unit consumption costs for transportation in urban and rural areas.

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[1] To define quality of transportation services, this study combined attributes describing coverage of the service area with service descriptors such as total hours of operation each week; whether special labor intensive services are offered to elderly riders; number of training courses taken by drivers; whether all trip requests are met; whether the agency has back-up vehicles; and advance reservation time required. A standardized score was developed to rank all providers from high quality to low quality.

Table 2

UNIT COSTS OF TRANSPORTATION CONSUMED
BY URBAN/RURAL CLASSIFICATION
(1982 dollars)

Area	Service Quality	Average Cost Per Trip	Range of Costs per Trip
Rural	Low Quality	\$6.57	\$1.59[1] - \$13.76[2]
	High Quality	4.60	3.30 - 7.83
	Average Rural	5.55	1.59 - 13.76
Urban	Low Quality	\$5.86	\$ .73[1] - \$14.47[2]
	High Quality	6.94	2.11 - 12.06
	Average Urban	6.35	.73 - 14.47
Average (all 49 providers)		\$5.92	\$ .73 - \$14.47

[1] These are systems with unusually high numbers of trips per mile or per hour.

[2] These are systems with unusually low numbers of trips per mile or per hour.

The cost per trip for transportation services also varies by agency type. The classification of service providers in the study sample by agency type and the related differences in cost per trip are shown in Table 3. Trips by public agencies cost approximately 19 percent more than trips by private non-profit agencies. Trips by single-purpose agencies cost more than trips by agencies with other management types. Trips by Community Action Agencies and government-based agencies cost more than those by aging services organizations or senior centers.

Urban/Rural Cost Differences

There are overall differences in the costs of services to the elderly that reflect the service provider's locale. Sometimes these differences were due to the costs of basic service inputs, such as labor hours; sometimes they were due to particular practices, such as the tendency for larger offices for in-home providers in urban areas; and sometimes they were due to consumption patterns of the elderly being served. These factors are summarized in Table 4.

Table 3

UNIT COSTS OF TRANSPORTATION CONSUMED BY AGENCY TYPE

Agency Type	Number of Agencies	Average Cost Per Trip (1982 dollars
Organization Type		
o private non-profit	38	$5.67
o public	11	6.75
Management		
o single-purpose agency	12	$6.44
o independent unit with central planning unit	6	5.17
o part of consolidated multi-purpose agency	31	5.89
Agency Base[1]		
o aging services agency[2]	14	$5.43
o community action agency	10	6.88
o city or county government[3]	6	6.29
o senior center	14	4.84
o others	5	6.69
Average Cost (all 49 providers)		$5.92

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[1] Agencies were classified into mutually exclusive agency base categories as follows: Aging services agencies were agencies planning, administering, or providing services to the elderly. In this sample, 11 aging services agencies were private non-profit organizations and three were public agencies. Government agencies performed the same functions through public agencies for the elderly and other clients as well. Community action agencies were those organizations established to serve the poor, some of whom are elderly. All ten community action agencies contacted in this study were private non-profit organizations. Providers of limited services to the elderly from one specific location were classified as senior centers.

[2] In this sample, one of the 14 aging service agencies directly providing transportation services was an Area Agency on Aging.

[3] In this sample, two of the six county government agencies directly providing transportation services were Area Agencies on Aging.

Table 4

SUMMARY OF COST DIFFERENCES FOR TRANSPORTATION SERVICES IN RURAL AND URBAN AREAS

Cost Factor	Rural		Urban
Administrative Costs:			
Overall Administrative Rates			
o General	----		----
o Transportation			Higher
Space Costs			
o Rent per Square Foot			Higher
o Other Space costs	----	Same	----
Equipment	----	Same	----
Other Administrative Costs	----	Same	----
Administrative Labor			
o Wage Rates			Higher
o Fringe Benefit Rates	----	Same	----
Direct costs:			
Operating Labor			
o Wage Rates			Higher
o Fringe Benefit Rates	Higher		
Fuel and Oil	----	Same	----
Maintenance			Higher
Insurance	Higher		
License and Registration			Higher
Unit Costs:			
Cost Per Mile			Higher
Cost Per Trip			Higher
Cost Per Vehicle Hour Available			Higher

Source: 1983 survey conducted by the Institute for Economic and Social Measurements, Inc. of 49 transportation providers serving the elderly.

The overall pattern that emerges is one of higher transportation costs in urban areas. Most transportation costs — including space costs, administrative wages, direct service labor, maintenance, and licensing -- were higher in urban areas. Although service consumption was higher in urban areas, this did not offset the production cost differential, and all unit costs were higher in urban areas: cost per mile, cost per trip, and cost per vehicle hour.

Administrative Costs

Labor costs are considerably greater in urban areas due to higher hourly wage rates. Fringe benefit rates do not vary between urban and rural areas. While the amount of office space used for administration do not vary between rural and urban areas, space costs are greater in urban areas did due to the fact that rents in urban areas are almost double. Office equipment costs and other administrative costs also do not vary with the urban/rural nature of an area.

The general administrative expense rates averaged about 21.5 percent and do not vary considerably between urban/rural areas even with higher rent and labor costs in urban areas. General administrative rates do vary by the type of agency with single purpose agencies and independent units with central planning units having higher rates than consolidated multi-purpose agencies. Also, aging service agencies have higher rates other than organization. However, given the small number of cases in each agency category, these variations were not statistically valid.

Transportation administrative expense rates average around 35.2 percent. While they are not highly correlated with the urban/rural nature of an area, transportation administrative expense rates are slightly greater in urban areas. As with general administrative rates, transportation administrative expense rates also vary with the type of agency operating the service. However, in this case, the governmental agencies and service centers have higher rates than aging services or community action agencies. Since the reverse is true for general administrative rates, it may be that a tradeoff is being made in agencies between what is called general or transportation administration.

Operating Costs

Transportation operating costs are separated into three categories depending on the output measures which effect cost:

1. vehicle miles
2. hours of vehicle availability
3. number of vehicles

Operating costs dependent on vehicle miles include fuel and oil maintenance costs. Urban areas have slightly higher costs per mile in this category. Data in the study indicate that fuel/oil costs do not vary by urban/rural areas; rather, they vary considerably by vehicle type (larger vehicles consume more fuel per mile). Fuel and oil costs average $.165 per mile. Vehicle maintenance costs vary by both urban/rural area and by vehicle type, with urban areas and larger vehicles having higher maintenance costs per mile.

Operating costs dependent on vehicle hours include driver and dispatcher wages and fringe benefits. Urban areas have appreciably higher costs in this category. While the ratio of paid driver hours to vehicle hours available is slightly lower in urban areas, ratio of dispatcher hours to driver hours is considerably higher. In addition, even though fringe benefit rates are higher in rural areas this is probably due to the fact that wage rates for both driver and dispatcher are much higher in urban areas.

Operating costs dependent on the number of vehicles being operated include vehicle insurance, license and registration and vehicle storage costs. Both insurance costs and registration costs per vehicle are higher in urban areas.

Unit Costs and Production Rates

Differences in the above costs translate into higher costs to produce a unit of service output (a mile or hour of service) in urban areas. The cost per mile of service is over 50 percent greater in urban areas and the cost per hour of vehicle availability is almost 14 percent greater in urban areas.

As expected, production rates are also higher in urban areas due to higher population densities. Trips per vehicle mile are 31 percent greater; trips per available vehicle hour are 41 percent greater and miles per available vehicle hour are 26 percent greater in urban areas.

This brings us to the most important service unit cost — cost per trip. Data from this study indicate that even though production rates are higher in urban areas, this does not totally offset higher unit production costs. Thus, the overall cost per trip is 13 percent higher in urban areas; $6.35 per trip in urban areas as compared to $5.55 per trip in rural areas.

CONCLUSION

The research project described developed a resource-based cost analysis methodology to

1. document and analyze existing transportation services costs, and
2. provide a basis for a hands-on cost analysis manual for use by service providers.

The formal cost structure presented can be used by a wide variety of agencies to establish their own true costs of many kinds of services, including the transportation services discussed here.

Special attention was paid to urban/rural cost differentials. It was expected that overall per trip costs in urban and rural areas would be similar despite large differences in individual cost components. We thought that the larger urban salaries would be offset by the greater distances traveled per trip in rural areas. To some extent, this was true, but trips for the elderly in urban areas still cost one-seventh more than trips for the elderly in rural areas.

(This draft version will be pre-printed for the Conference. A shortened version will be published in the Conference Proceedings).

A Review of Crash Protection of Children, the Elderly. and the Handicapped, and the Design of Inflatable Compartmentalized Controlled Deformation Protective Systems for Them

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Note: The oral presentation will be a demonstration of the concept of crash protection, dropping an egg in a protection system, and a discussion of motion pictures illustrating key points, including films of early inflated structures research).

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Abstract / Introduction

Following reviews of the histories of crash protection for children, the elderly, and the handicapped, and of the early development of airbag crash protection systems, this paper presents design requirements for the transportation crash protection of these groups, which share possibly decreased neuromuscular control, bone strength, and local tissue load tolerance in comparison to healthy young adults. Designs of inflatable compartmentalized systems which can meet major aspects of these design requirements are then presented. A design of an inflatable protective systems for the elderly hip, often broken in a fall, is presented. These designs have not yet been built.

A Brief History of Crash Protection for Children

I present transportation protection for children to this conference on Transportation of the Elderly and the Handicapped as background for what can be done to provide crash protection. Also, many of the handicapped in transport are children. A small child properly secured in a well designed child safety seat in the center rear position has the greatest protection yet provided to anyone in passenger car crashes. It is not unknown to find small child survivors in small child safety seats in crashes in which all adults are killed (1). However, the potential remains for additional improvements in child restraint design, particularly for handicapped children, and road and car structure and crash avoidance systems designs, although the greatest initial benefit to society will come in getting the available protective systems, including manual belts, utilized, and in the proper rather than the all too common misuse modes [(2) - 75% of the small child safety seats in use seen in this study were misused by incorrect child harness attachment, misrouting of the seat belt, or the lack of attachment of a tether if required]. Children are our most precious resource; the benefits to society of saving children in crashes warrent this additional research design effort. Is it necessary or acceptable that any child die in an automobile accident?

Protection of infants and small children in transport (carrying) may be considered "instinctive." Stone age cultures today, and probably tens of thousands of years ago, use thongs and garments to tie infants and small children to mothers - the first child restraint systems. The author has seen in a Munich museum an early nineteenth century child sleigh, with a hand bar for pushing by an adult, with a lap bar put into place after the child is seated, as a restraint. Special seats for carrying children in automobiles began to be sold in 1933 (3).

The first (United States) Federal Motor Vehicle Safety Standard (FMVSS) final rule for infant and child protection, 213, was published in 1970, to include static testing of the strength of the restraint (able to withstand a pull forward of 1600 pounds: a 40 pound child in a 40 G crash) and its attachment to the motor vehicle (4). In 1973, a reduction to 1000 pounds of the static strength requirement for the child restraints was made. The major improvement in this standard, effective in January, 1981, was to require a dynamic sled test, simulating a crash at 30 mph of a passenger car into a solid wall, with an infant or 3 year old sized dummy (4) in the infant or small child restraint. Other standards (4) cover the strength of the webbing, with the test method as part of FMVSS 209, and the strength of attachments to the motor vehicle (FMVSS 210). A more complete child protection standards review is presented by Radovich (3).

Infants are generally protected with a "five point" harness (attached at the shoulders, hips, and between the legs) while reclining in a couch which is attached to the car seat facing the rear of the motor vehicle, although infant beds, with the infant transverse to the vehicle's long axis and with a netting cover rather than a harness, are used outside of the United States and may be used here (5) if they pass the FMVSS 213 30 mph dynamic test, which requires that the infant dummy head and torso be retained in the bed throughout the crash test. For the greater protection of the backward facing condition, Weber and Melvin (6) recommend that infants be kept in backward facing couches as long as they fit, with an age approaching one year and a weight up to 24 pounds, if the infant couch has been tested to this level. The Century "Infant Loveseat" has passed such a test (6); the convertible infant seats are less strong, and should be used for an infant weight beyond present manufacturer recommendations only after further testing.

Small children able to sit up, generally over 6 months old and weighing over 18-20 pounds but less than 40 pounds, may be put in small child safety seats. In the initial design (7), these were backward facing, and continue to be used this way in Sweden, requiring additional attachments to the car than the lap belt alone, using multiple tether straps. This backward facing design gives a broad load distribution across the child's back in a frontal crash. The author recommends the development, marketing, and use in the United States of a backward facing toddler seat meeting the conditions of FMVSS 213.

In the United States, FMVSS 213 requires in part that a child restraint be attached in the car with a lap belt, or with one tether in addition if required by the manufacturer's design use mode, and so the small child safety seats are mounted forward facing. They must pass the 30 mph (24 G peak) frontal crash simulation test with a dummy head injury criterion (HIC) of less than 1000, chest resultant acceleration of less than 60 G, head excursion of less than 32 inches forward of the car seat back hinge or "Z" point, and knee excursion of less than 36 inches forward of point Z. The child safety seat must not change its adjustment position during the crash test, and no load carrying structural member may fail. If the child seat requires a tether, it must also pass the standard conditions in a 20 mph (18 G peak) simulated frontal barrier crash test with the tether disconnected.

Federal standards do not yet specify the performance conditions for child protective systems for children over 40 pounds (about the fourth birthday). These children, and small adults, up to about a height of 55 inches or age 11 for an average child, may be short enough that the shoulder belt in some cars rests flat on their face or neck, a dangerous condition leading to an abrupt head rotation in a crash. In other cars, much shorter people will have the shoulder belt properly on the shoulder rather than flat on the neck. People too short to use the adult shoulder belt may be tall enough when restrained only by a lap belt to have their heads hit the dashboard or the middle of the back of the front seat in areas not required to be softened by FMVSS 201. Of course, unrestrained, they may hit these same hard areas (8). The booster seat is an excellent solution, providing an elevation of the child so that the shoulder belt does not rest on the child's neck, or using a child double shoulder harness requiring a tether attachment. A Notice of Proposed Rulemaking to require the automobile manufacturers to provide tether attachment points in all cars has been published (9).

Tether attachments have a growing importance as booster seat sales and concerns for providing improved protection for 5 to 11 year old children increase. Small child seats without a tether can be designed and are available, passing the FMVSS 213 30 mph sled test. But upper body support, essential to prevent head contact for the older children (over 4) in the back seat can be provided by the car owner only by installing either adult shoulder belts [for which the strengthened attachment areas must be provided by the car manufacturers (4)] or one or more tether attachments for child double shoulder straps or harnesses. Some cars, notably by General Motors or Toyota, have provided strengthened areas for child tether attachment. For many other cars, the owner at present must install a strengthened tether attachment point behind the rear seat.

Indents or "wings" at the sides of the booster seat support the car lap belt to cause it to pass over the child's lower pelvis and thighs rather than on the abdomen, as car lap belts so often do when the child is in the back seat using the lap belt alone. For the taller children in the back seat, for whom the booster seat may elevate their heads above the back of the back seat, a booster seat back with a head rest is needed.

A recent study (10) of small child seats in design use and in misuse in simulated frontal and 30 degrees oblique crashes at 15, 25, and 35 mph using 3 year old sized dummies revealed that some small child seats under these conditions more severe than as tested in FMVSS 213 do have mechanical failures (structural rivet, tubing, and plastic failures), although the booster seat with upper body support performed very well. Weber and Melvin (6) also report mechanical failure of a small child seat in a simulated 30 mph crash under the common misuse condition of routing the car lap belt low on the child seat structure and not using a tether strap. It would be appropriate for child seat manufacturers to test their devices under reasonably expected (2) misuse conditions and crash speeds.

Federal standards apply to manufacturers, not to individual motor vehicle owners. They can specify that a restraint meet certain tests, but not that it must be used by the public. State laws, with state police enforcement, apply standards to be observed by the public. In 1977, Tennessee was the first state to mandate the use of protective systems for children under 3 years old (11). In August, 1984, Wyoming is the only State that has not yet passed mandatory child protection use laws (12). New York was the first state to extend the mandatory use of crash protection systems to age 10, even if the child is in the back seat (13). Adults in the front seat of a New York or out of state car must also use crash protection, after December 1, 1984, with fines up to $50 after January 1, 1985, for front seat adults, and for the driver if there are unrestrained passengers under age 16 in the front or under age 10 in the back (13).

Ejection of children from motor vehicles continues of concern, with some 1200 through age 14 being ejected each year and with one quarter of these being killed (14). Almost 6000 adults are ejected and killed each year, according to estimates based on police reports, with about half of the ejections being through glazing. Further applications of the new glass-plastic glazing offer promise in reducing these child and adult ejection deaths (15).

Dr. William Haddon, the first Administrator of the National Highway Safety Agency (which became the National Highway Traffic Safety Administration), has said (8),

> "There is no physical reason why most of these crashes, including the more violent ones, should result in death or serious injury. As is no surprise to any competent automotive engineer, the technologies have long been available to provide in all sorts of crashes - whether frontal or side, rear or rollover - protection against fatal and serious injuries far superior to that provided in today's vehicles. In the crash of a properly designed automobile, few occupants would be ejected, smashed about inside the car, crushed or bludgeoned by the passenger compartment's collapsing about them, or burned. This is equally true of vans and pickup trucks."

We have the engineering knowledge to provide safety in 50 mph barrier crashes (17), but we do not have the public decision to use this knowledge. Perhaps, however, for children, the elderly, and the handicapped, there is the extra sympathy that the protection to let most of these people survive crashes can be developed or put in place and used.

Crash Protection for Adults and the Elderly

Adult crash protection, which includes but does not separately distinguish crash protection for the elderly, is specified in FMVSS 208 (4), again with harness specifications in FMVSS 209 and attachment specifications in FMVSS 210. No special precautions are mandated for the elderly, although research continues in showing the decreasing bone strength with age, and hence the greater number of rib, sternum, and clavicle fractures produced by belts or other contact forces in crashes as age increases. For example, based on cadaver data (18), in a 30 mph frontal barrier crash, a 20 year old adult male would be expected to have two or three thoracic fractures, usually under the shoulder belt. A 60 year old male might have 15 thoracic fractures. Studies of road accidents of car occupants wearing lap and shoulder belts (19, 20, 21) do not indicate so many thoracic fractures due to shoulder belt loads, for living car occupants of comparable age as opposed to cadavers in sled tests. However, some level of decreasing bone strength with age is generally accepted.

Crash loads may be more severe than the 30 mph barrier crash test condition of the FMVSS 208 standard (and many others of our standards). Indeed, about half of the car occupant fatalities occur with a crash change of velocity ("delta V") of more than 30 mph (22). The 30 mph delta V design condition for even the belt restrained must prevent death, but can produce a significant number of serious injuries (Abbreviated Injury Scale or AIS = 3) (20). NHTSA standards are not yet set to prevent injury under all reasonably expected conditions of use, as safety standards are intended to do in most other fields (24).

The elderly should be particularly careful to use all available crash protection, especially an airbag with a lap and shoulder belt as well, select the safer cars (25), which are generally but not always the larger cars, and drive particularly carefully. The elderly should encourage the availability of airbags, which provide a better chest load distribution. These are now (August, 1984) available only for drivers in certain Mercedes-Benz cars.

The history of seat belts has been well reviewed by Johannessen (26). Recent events affecting passive restraints are as follows: In 1977, FMVSS 208 was modified to require passive restraints in large cars by 1982 and in all cars by 1984,(27). In 1981, the passive restraint requirement was recinded (28) as economically unjustified in that the automobile manufacturers were expected to use passive belts, which were more expensive but were expected to lead to little more use than with manual belts. The majority not using belts would simply disconnect the passive belts. Following judicial appeals, in 1983 the Supreme Court directed (through the Court of Appeals) that the Department of Transportation reconsider the passive restraint requirement (29).

On July 11, 1984, the Department again modified FMVSS 208 (30) to require that in the 1987 model year, at least 10 percent of the passenger cars sold would contain passive belts, or alternately at least 6.7 percent would contain airbags or other passive restraint means than safety belts, or some combination of cars with different passive restraint means may be used. These alternate means were to count 1.5 times as much as the use of passive belts. In successive model years, the percentage of passive belts (with the lesser percentage for other passive alternatives) must climb to 25 percent, and 40 percent, with 100 percent provision of the "frontal/angular automatic protection system...at each front outboard designated seating position [which meets] the frontal crash protection requirements...by means that require no action by vehicle occupants" by the 1990 model year, but with the proviso that if states representing two thirds of the population had passed mandatory seat belt use laws by April 1, 1989, the passive restraint requirement would revert to an option. New York state was the first with such a mandatory safety belt use law (13).

Crash Protection for the Handicapped

Col. John Paul Stapp has written (31),

> "The automobile has become civilized man's locomotor prosthesis. He can get along more comfortably without one of his legs than without a car."

But this essential "locomotor prosthesis" is used with an accompanying price in deaths and injuries which can at least be cut in half by using safety belts, and might be cut 75 to 80 percent by further modest development of known crash avoidance and crash protection principals.

The handicapped, often with reduced neuromuscular control, bone strength, and local tissue load tolerance, are in particular jeopardy in motor vehicle crashes. Yet the standards for their protection in crashes are still rudimentary or non-existant. As an example, FMVSS 222, School bus passenger seating and crash protection, excludes "a seat installed to accomodate handicapped or convalescent passengers as evidenced by orientation of the seat in a direction that is more than 45 degrees to the left or right of the longitudinal centerline of the vehicle." As a consequence, a great many makeshift devices have been developed or used by the local school or transportation group, more to retain the handicapped person (or at least his wheelchair) in place during normal driving loads than to protect against crash loads. The NHTSA has not proceeded with writing standards for crash protection of the handicapped.

The Education for All Handicapped Children Act of 1975 (32) was passed to assure that handicapped children would have access to public education - by requiring schools to provide transportation and class access for these children - "mainstreaming" them instead of leaving them as a low priority social problem for others to deal with. With the obvious reduced neuromuscular control of body posture of cerebral palsy children, for example, body support during normal driving is needed; support for everyone in a crash is a less obvious need. Similarly, the needs of the handicapped in driving their own vehicles are more obvious than their needs when they get in a crash. Many of the handicapped are already on public funds; the costs of injuries are also largely public funds, although generally from different budgets or even agencies. The short term "savings" of ignoring potential accidents could become losses of public funds if crash protection is not part of the expenditure.

With some 20 million children being carried to school in buses each day (22 million in 1981), there are, each year, involving school buses (33)

	Average, 1975-1979	1981
fatal accidents	134	143
school bus occupant fatalities	17	14
occupant fatalities in other motor vehicles	80	81
pedestrian fatalities	43	48
pedalcyclist fatalities	5	

Some 40 percent of the school bus fatal crashes are single vehicle crashes, going off the road or hitting a pedestrian or a bicyclist. Some 60 percent are multiple vehicle accidents. We have no accident investigation record of a wheelchair occupant being killed in a motor vehicle crash. Although a tabulation is made of every fatality, in the Fatal Accident Reporting System (FARS) (34), the tabulation and analysis of injuries, by the National Accident Surveillance System (NASS) (35), is by a statistical sampling for followup of police reports of crashes, by 50 accident investigation teams (August, 1984) across the country. The sample is still small; in 1982, 8,718 crashes of an estimated 5,825,000 police reported crashes were documented in NASS (35). Hence, low frequency events, such as an injury to a handicapped person, are not yet reliably sampled. Indeed, the NASS computer coding does not yet include that a person was handicapped in a particular way prior to a crash.

In 1977, with a total U.S. population of 217 million, estimates of persons with selected impairments were as follows (36):

	Total	Not employed
blind and visually impaired	11,415,000	7,047,000
deaf and hearing impaired	16,219,000	9,486,000
speech impaired	1,995,000	1,489,000
paralysis	1,532,000	1,207,000
orthopedic handicap - upper extremity	2,500,000	1,178,000
orthopedic handicap - lower extremity	7,147,000	4,023,000
absence of major extemities	358,000	232,000

The mentally ill and developmentally disabled populations are not included in this table. Note that some persons have more than one impairment. Depending on the selective life activity of the handicapped person, the disability, or impairment of intended activity, can be very small or complete. Approximately 58 percent of the impaired persons are married, the same as the U.S. population as a whole. Four fifths of the impaired live with relatives (36). A significant part of the non-vision or hearing handicaps are produced by injuries (37), with motor vehicle crashes a major source. Some 56 percent of the estimated 6800 acute spinal cord injuries in 1980 (38) and 44 percent of the estimated 179,000 brain injuries treated by a physician (39) were due to motor vehicles.

From 1978 state developmental disabilities plans (36), the estimates are

	Total	Substantial handicaps
mentally retarded	9,560,000	3,414,000
epileptic	2,386,000	1,034,000
cerebral palsied	912,000	524,000
autistic	71,000	67,000

Many of those who are epileptic (40) or mentally retarded developed the condition as a consequence of motor vehicle accidents. We are just beginning to appreciate the long term significance of head injuries (41), with again a major part from motor vehicle crashes. The state "developmental" disabilities rolls contain many people who are there because of the "development" of having experienced a motor vehicle crash without adequate protection, although I have not yet found estimates of the cumulative numbers of motor vehicle disabled.

From a 1972 study (36), 87 percent of those with disabilities report no mobility limitations for the activities they continue. Some 1.8 million are estimated from the sample to recognize mobility limitations needing the help of another person not in the home, of which 0.6 million need help in transportation and the rest need help in and around the home, including 0.9 million confined to the home. It is noted that the life horizons of the handicapped may often drop below what could prevail. Thus a man who uses crutches who rarely goes out may say that he has no mobility limitations for the life activities he has accepted - but with support and encouragement, he too might become President.

A 1973 study estimated the national transportation services needed by the handicapped (42), using 1970 data:

Handicapped -	Under 65	65 and over	Total
Non-ambulatory			
Cannot leave home	878,000	878,000	1,756,000
Acute condition	185,000	50,000	960,000
Institutional	30,000	930,000	960,000
Ambulatory			
Demand responsive service with lift for wheelchair	230,000	200,000	430,000
Demand responsive service without needing the lift	923,000	953,000	1,876,000
Conventional transit vehicles with special features	4,784,000	3,329,000	8,113,000
Totals	7,030,600	6,340,000	13,370,000

Note in the above the 430,000 wheelchair users who wish to use motorized transportation, with about half over 65 years old.

An NIHR Long Range Plan summarizes (43) on page 3 as follows:

> "The number of physically and mentally handicapped persons in the United States is estimated at between 25 and 35 million - from 10 to 15 percent of the total population. Of these, perhaps 10 million are severely disabled.
>
> The economic impact of disability is measured in the hundreds of billions of dollars annually. In 1975, $114 billion - amounting to 7.5 percent of the gross national product - was spent on transfer payments and medical payments attributable to disability and direct services to the disabled. This figure does not include the huge loss of earnings resulting from disablement of wage earners.
>
> ...(p.1) NIHR itself is capable of performing only a portion of the research required. Other Federal agencies have statutory and program responsibilities - and often unique capabilities and experience - in this field.
>
> ...(p.47) The 1978 amendments to the Rehabilitation Act provide the authority and impetus, through the Interagency Committee on Handicapped Research, to share resources and information and even to cooperatively develop research projects in areas of mutual concern. To a great extent, the success of the long-range plan will depend on the effectiveness of the interagency structure established to coordinate the vast assets of Federal agencies."

The wheelchair has been of particular concern, because unrestrained it can cause injury to others as well as the user. In 1977, the Veterans Administration held a workshop on wheelchair design (44), and published draft standards (45). These mention the "stress of normal usage," and include effects of bouncing off a 15 inch curb 3600 times, but say nothing about vehicle tiedown. As the more severe loads of motor vehicle crashes (above 15 G) were applied to wheelchairs with the then available tiedowns (46, 47, 48), it was clear that most wheelchairs, and tiedowns gripping the wheels rather than a strengthened wheelchair frame, were inadequate, with severe structural failures in the crashes. A design considered suitable for Canadian train use for wheelchair tiedown and occupant belt support was developed and tested to 5 G (49).

An excellent motor vehicle crashworthy design with a rear facing padded restraint back attached to the floor, to which the wheelchair is attached by cables during transit, and with a three point harness for the wheelchair occupant, has been built and tested (50), but this has not been built commercially. This design does not correct for the structural weakness of most wheelchairs, but with the occupant harness attached to the padded restraint back, considerable protection would be provided even if the wheelchair collapsed. A National Conference on Wheelchair Securement in Transit was held in December, 1980, sponsored by the Urban Mass Transportation Administration and the Department of Transportation (51). The Conference report lists the participants, and the manufacturers involved in tiedown work. Sled testing continues to lead to improved structural integrity in crashes of wheelchairs such as the Orthokinetics, Inc., travel wheelchair, and the molded shell body support orthotic seats manufactured by American Orthopedic Services, Inc. (52).

In January, 1983, the National Institute for Handicapped Research (NIHR) arranged a workshop on the Personal Licensed Vehicle (53), the car or van operated by the handicapped person. After a review of the issues of crash avoidance (control) and crashworthiness, this group from government, universities, and industry involved in aspects of handicapped transportation voted to ask the Society of Automotive Engineers to establish two committees to develop voluntary standards for personal licensed vehicle controls, and for crash protection of the handicapped, particularly of the wheelchair driver of a personal licensed vehicle.

In this same period, NIHR established a new Rehabilitation Engineering Center at the Louisiana Technical University, to improve selection and training procedures for handicapped operators of personal licensed vehicles. NIHR made a grant to the SAE to pursue the standards efforts, with part of it to go to the University of Michigan Rehabilitation Engineering Center (Dr. John Melvin, Director), for continued crashworthiness and other studies for "mobility, transportation, and delivery systems for the physically handicapped." Instead of two committees, the SAE has formed one, the "Adaptive Devices Subcommittee" of the SAE Human Factors Engineering Committee, with Dr. DeWayne A. Landwehr, of the GM Technical Center, as Chairman. Dr. Landwehr assured those participating that the Subcommittee will also be concerned with the crashworthiness issues (54).

An excellent review of the problems of supporting in seats and transporting handicapped children has been written by Suzanne Hauser Holland (55). Again, these problems are supporting the child, who may have inadequate muscular control, against the braking and turning loads of normal driving and indeed sitting in school, and supporting the child in the crash situation. Harness and vest restraints are available which deal with these problems (56). The most complete design thus far is the Britax Handicapped Child Safety Seat (57), which has a shell able to accomodate children from 20 to 80 pounds and up to 5 feet tall. This has an adjustable harness, and adjustable padding and head supports, to provide the needed support. It is expensive.

Velcro is a fabric material with many small hooks and eyes, which can secure padding or support around a person yet can be easily separated. Wide Velcro strips can indeed support a child against normal driving loads, but we have been cautious that the strips would be torn apart under crash loads, and generally recommend that in crash restraints Velcro can be used to provide comfortable adjustment to size, but the restraint should also include harness or webbing material which cannot separate in a crash. There has been one published test (58) with doubled Velcro replacing the shoulder straps for a three year old; the Velcro did not separate. Our caution continues, however, that lint or age might decrease the Velcro separation force, and higher subject weight or acceleration could separate the material. This warrents further study, because wide Velcro closures may be easier to use than some belt buckles.

The handicapped adult has inadequate protection provided. As a car passenger, he cannot yet get an airbag system. He can get a physician's excuse so that he will not have to use uncomfortable or dangerous (for him) belt systems, but this will not protect him in a crash. It is to deal with this lack that the conceptual airbag designs at the end of this paper are presented.

An Early History of Airbag Crash Protection Systems

Several people independently invented deformable airbags or inflated airpads or aircushions for the crash protection of humans. I was one of these, but not the first. Most of the others described the idea, or made sketches, or even got patents, initially unknown to me, but were not able to demonstrate the feasibility of the airbag protection concept, which in the period prior to 1964 was often ridiculed. I was fortunate enough to work for a company, the Martin Company, Baltimore Division, that let me do some experimental work before getting outside funding. In 1962, I made the first public (and perhaps private) crash tests simulating a vehicle with an airbag protective system.

I was initially concerned with protecting astronauts in spacecraft landings, and so experimented with full length "couch" airbag systems. After my initial human experiments crashing in airbags, I received the first U.S. (and apparently any) government contract, from the National Aeronautics and Space Administration (NASA), to design and test human airbag protection sytems, initially for astronauts but then amended to cover aircraft and ground transportation vehicles. In the period since my work, airbag technology has been thoroughly developed for automobiles, although this technology has not yet been widely adopted, largely on economic grounds. If airbag protection came as cheaply as belt protection, I expect that airbags would be in most automobiles. My present interest is to consider the application of inflatable system technology for the normal driving support and crash protection of children, the elderly, and the handicapped. The last, particularly, have special needs for support inadequately provided by the lap belt and shoulder strap, including support for their special casts or braces.

My introduction to acceleration protection problems (59) was as head of the Biophysics Division of the Naval Air Development Center's Aviation Medical Acceleration Laboratory, which had then the world's largest human centrifuge, in the period of 1955 - 1961. I was Project Officer for the development of computer controls of the human centrifuge, and for the then made possible Centrifuge Simulation (and pilot training) of the X-15 Research Aircraft, and the Centrifuge Simulation (and astronaut training) of the Mercury Spacecraft.

During the Mercury Program, to provide broad back surface support of the astronaut during atmospheric exit and reentry, polyurethane "contour couches" inserts were cast to the individual astronaut's shape in his pressure suit. These inserts had to be changed as we made successive flight simulations with different astronauts. I wished to have a "universal" couch, which would accomodate to fit any astronaut. I was impressed in 1960 through my centrifuge experience during the developmental testing with the "interchangeable mobile pilot restraint system" of Vykukal et al. (60), which used thin air bladders to tighten the restraint on the subject, allowing the pilots to share a common restraint attachment.

In April, 1961, I joined the Martin Company as head of the Life Sciences Department. In our Apollo (lunar landing program) proposal work, I pointed out that the massive couch dominates the center of the spacecraft, but needs to be strong or present only during the few minutes of high acceleration in the several days of a lunar flight. I suggested an inflated restraint, pressurized to support the astronaut when needed, then deflated out of the way. Small tethers could support the astronaut at the control panel during zero G flight. This concept needed development before flight application.

A May, 1962, proposal (61) to the National Aeronautics and Space Administration (NASA) to build a "multi-gradient yield" (multi-layered compartments) inflated restraint was not funded, but an internal Martin study of the possibilities of impact and vibration protection with full length airbags above and below the subject was authorized in 1962, and carried out (62), although the multi-layered compartments aspect was not developed. NASA, in January, 1964, then funded, with contract NASw-877 from the Office of Biotechnology, Mr. John Fuscoe, Contract Monitor, the development and testing of a larger "pilot compartment airbag restraint system," with 30 inches of available travel in any direction, simulating a spacecraft interior.

As this work progressed (63, 64), we recognized that crash protection was more pressingly needed in aircraft, and particularly in motor vehicles. Four addenda to the NASA contract were awarded to let us consider protection for these other means of transportation. We modified the airbags for the seated position, and built the first "airseat" inflated seat structures to,provide, by adjusting pressure, controllably deformable protection behind as well as in front of the occupant. We tested or arranged with NASA and other crash testing programs, to test the airbags and/or airseats for the first public (and possibly the first public or private) crashes with airbag restraints in a spacecraft simulator, a large commercial aircraft (a DC-7 experimentally crashed by the Aviation Safety Engineering and Research - AvSER - Group of the Flight Safety Foundation in Phoenix on April 24, 1964), two small military aircraft, a helicopter, a passenger car (a right front passenger pre-inflated airbag with a dummy in a car which hit the back of a school bus at 60 mph on April 16, 1966), and school buses (the last two in cooperation with the vehicle crashes of Derwyn Severy, Institute of Transportation and Traffic Engineering, University of California, Los Angeles). These test had their failures as well as their successes.

Gradually in 1962 - 66 through our publications, speeches, and films, people learned about the crash protection possibilities of airbags who were in the technical world, the public, the government (Dr. William Haddon, the first director of the new highway safety agency developed his concept of "passive" crash protection, without any action by the occupants, using our airbag work as a prime example), the Iowa legislature (where I testified in support of automobile safety legislation in 1965), and the U.S. House of Representatives (where I also testified in support of establishing a Federal presence in automotive safety, reference 65) - and Ralph Nader (66). In this period, the technical details of the work of the automobile industry and suppliers on airbag protective systems, still only partially published, was then kept secret, although the fact that the auto companies had worked on airbags and found all kinds of problems was discussed in response to our work.

Nader, in 1965, wrote (66), "Protection ... could be achieved by a kind of inflatable air bag restraint which would be actuated to envelop a passenger before a crash. Such a system has been recently experimented with for airplane passenger protection " [speaking of our work]. "Both Ford and General Motors did work on a system like this about 1958 but dropped the inquiry and now refuse to communicate with outside scientists and engineers interested in this apporach to injury prevention." It is my present impression that their sled and car crash tests may have followed the start of my crash tests in 1962, although their paper and bench laboratory studies preceeded our work (65), in secret.

As to our successes and failures, the tests of spacecraft landing and vibration simulation were all successes. In the April, 1964, DC-7 crash (63), on-board acceleration recordings were lost, but our dummy with airbags is seen from the films to be well supported whereas most of the others lost a head, hit the floor, or had catastrophic seat failures.

In November, 1965, we made sled tests at the FAA/Atlantic City catapault track (64, 67) of the airseat/airbag protected dummy. The airseat, with its continuously deformable inflated structure, with tension members to hold the shape so that it (in design concept) looks and feel like an ordinary seat at 1 G, does not suffer the abrupt metal failure modes of present seats. Think of the outer envelope as of a lap belt as wide as the seat, and with the inflation reliability of a tire. We had expected to go to a sled speed of 60 mph. When the protection (with the longer duration pulse than in an automobile crash) was still excellent, we went on up in speed. At 71 mph, the standard aviation seat behind the airseat and its lap belt broke, flinging its dummy onto the ground. The airseat/airstop dummy loads were still in the uninjured range. At 87 mph (103 mph delta V with catapault arresting cable rebound) - and it was this run that Philadelphia television arrived to cover and show that night - bolts failed and the sled superstructure broke in half, dropping the front of the superstructure with the airbag on the back of the seat in front onto the ground. The airseat with the lap-belted dummy remained on the sled base, but with the upper body support gone. Chest loads peaked at 27 G resultant, with -24 gx on the sled. This test appeared to be a failure, yet showed a lot of promise for the airseat/airbag concept.

In the April, 1966, car crash at 60 mph into the back of the school bus (69), the car underrode the bus body, with the car hood being rolled back and penetrating the windshield. The dummy head accelerations were -20 Gx at 58 milliseconds (ms) - head stopped by the airbag, +25 Gx at 75 ms - rebound into the seat back, -50 Gx at 90 ms - the second stopping of the head by the airbag, -1 Gx at 102 ms, then -109 Gx at 112 ms and -10 Gx at 120 ms - the impact of the head against the penetrating hood, I surmise. The airbag was torn by the penetration; the appearance was that the airbag had failed. Derwyn Severy wrote (67), "A three point safety belt would have restrained him so that no component of his body would have sustained anything approaching the 109 G he sustained." This would be true only if the hood would not have reached his head if he had been in a three point belt. Indeed, the picture on page 247 of a 1967 Severy article (68) shows this crash at perhaps 100 ms. The rolled up hood is just coming into the passenger compartment. The left rear unrestrained dummy has been thrown forward onto the back of the front seat. The right front passenger is seen properly supported with the airbag still in front of him. This test was not an airbag failure but a marginally survivable compartment penetration event.

In the school bus crashes (67), the airseat was inadequately used with just a lap belt, and no forward airbag, but still provided better protection than the regular bus seats when struck from behind. The airbag was very interesting in that it provided protection for the dummy behind it - and also provided protection for the flying arms and legs of other unrestrained dummies repeatedly striking the airbag later in the crash, as seen from the films. If all the free space in the school bus had been filled with airbags, injuries would have been greatly reduced.

In all of our crash work, we pre-inflated the airbags, planning for the subsequent system development to use explosive diaphragm inflation from a high pressure tank if pre-crash triggering (by radar, etc.) of slower inflation at a lower source pressure could not be developed. Indeed, in aircraft, human crash anticipation and manual triggering of the airbags could be used in most crash situations. (Radar crash anticipation triggering of airbag inflation was studied by the Toyota staff, as reported at the First ESV Conference in 1971, reference 23).

We developed a prototype airbag with coil springs (63) which could be remotely inflated and automatically deflated and rolled up for reuse, for use under pilot command in aircraft takeoffs and landings, which has not been further developed. We developed a prototype high speed train airbag system (69), including airbags for those in the aisle when an emergency developed. I particularly regret that the airseat, with its controlled deformation protection, has not been further developed for aircraft or automobile use. The alternative to softening the rebound loads by softening the seat has been to vent the airbags to reduce rebound, done at the price of reducing high speed airbag protection.

We developed an inflated stretcher or "airlitter" system (70), with the first "multi-gradient yield" or multi-layered construction, with the outer compartment at 5 psi to hold structural shape (the airlitters could even be piled on top of each other, and quickly secured in aircraft with straps), and with the inner airbags at a few inches of water pressure, to provide occupant comfort. This system could be unzipped to provide open field hospital beds. I made a low speed swing test in this airlitter, and we made some drop tests and a helicopter crash test, showing its protective value.

Our work at the Martin Company has been criticised as not involving airbag systems. This is correct; our work involved pre-inflated airbags, airseats, and airlitters. We did nothing with the engineering problems of impact sensor design and triggered pressure release, stressed by the automobile industry (71). But the initial question in considering the feasibility of airbag protection had to be whether the flimsy structure of an airbag could safely stop a person in a crash. Just as the French in their initial airbag work (72) used pre-inflated airbags to answer the biological question of whether airbags, if all the engineering problems of getting them in place could be solved, could provide adequate (and improved) support in a crash, so our human and dummy experimental work significantly contributed as the first public answer in the affirmative, indicating the potential load reduction and broad load distribution of inflated protective systems, and perhaps even preceded the dummy crash experimental work of the automobile and supplier industries. Our work set the climate for the automobile companies to take a more intense and public look at airbag protection, in response to questions by public officials and others.

After our work, the next human experiments (73) with airbag crash protection were carried out initially and briefly with preinflated airbags which for the large airbags and pressures used were too soft, and then with rapidly inflating airbags and lap belts, at up to 22 mph delta V, with 9 to 12 g on the sled. Baboon studies (74) were extended to 60 mph impact speeds, to show airbag protection to more than -120 Gx on the chest. Less injury was obtained in these frontal crashes with the airbag alone than with the airbag and lap belt.

My highest speed airbag test was a 16 foot drop of the spacecraft simulator into sand (63) - an impact velocity of 22 mph, a peak deceleration of the structure of 69 G, a peak load on my chest of +14.6 Gx (supine), and my displacement into the bottom airbag of 20 inches. Similar drops were made at 45 degrees feet down and 45 degrees to the side, to show that the spacecraft lander did not have to be perfectly aligned with this system. No venting was used; the crash felt like three quick taps, over in a second, with an amplitude attenuation of about 50 percent per cycle. The system was ready to take repeated impacts. I recommend that further work be done on airbag systems for future spacecraft landings.

In May, 1966, Carl Blechschmidt and I proposed an "Automobile Passenger Airstop Restraint Program" (75) to the Bureau of Public Roads, Department of Commerce. This was received with interest, and negotiations were proceeding for funding. But with the creation of the National Highway Traffic Safety Agency a few months later, this program was not funded. The new agency took over responsibility for motor vehicle safety, and the staff wished to study the broad issues before funding specific solutions.

With Martin-Baltimore not winning sufficient space programs, the space program there was largely phased out in 1966. In November, 1966, I became Deputy Director of the Science and Technology Divison, Reference Department, Library of Congress, and for the next eleven years worked in information and consumer product safety issues, publishing only one review of the airbag work (69), including the airlitter and train airbag systems. In October, 1977, I returned to motor vehicle crash protection work, joining the National Highway Traffic Safety Administration.

The Airbag Work of Others

As we at the Martin Company began to design commercial airbag restraint systems, the patent lawyers explored the patent status. The Martin Company elected not to patent our work on an aircraft airbag system, the airseat, and the airlitter; I believe Carl Blechschmidt and I received two $25 patent disclosure awards.

Patents were an area of literature with which I was not familiar; many patents go unmentioned in the other engineering literature. It soon became apparent that several people had described airbag ideas, and received patents. The earliest airbag patent we found was U.S. Patent 2,649,311, filed by John W. Hetrick on August 5, 1952, and granted on August 18, 1953, although F.G. Manson received U.S. Patent 2,057,687 in 1935 for a seat structure that used inflated layers to adjust the height, and there are patents on inflated structures not using deforming airbags as a protective system. Hetrick's patent covers safety cushions for automotive vehicles which are automatically inflated when there is a sudden slowing down of the vehicle. These cushions would be mounted on the steering wheel, glove compartment, instrument panel, back of the front seat, etc.

R.H. Hodges received U.S. Patent 2,755,125 on July 17, 1956 (filed June 8, 1955) for "inflatable crash protection for vehicles," with an airbag pictured over the windshield. H.A. Bertrand received U.S. Patent 2,834,606, "Safety Device for Passengers," on May 13, 1958 (filed October 6, 1956). This involved airbags essentially filling the passenger compartment. As far as I have determined, none of these people published experimental results of human airbag restraint tests in the open literature, although Bertrand approached Ford (71) with his later patent, 3,197,234 of July 27, 1965 (filed June 10, 1963), which Ford rejected due to the excessive airbag filling time (71). Many other patents have followed, but none involved experimental work with human airbag restraints in crash environments earlier than 1962.

After my early airbag work, I received from Jerry Lederer a copy of a letter that had been written on May 1, 1941, by Mr. Jo Kotula, Morristown, New Jersey, to Hugh DeHaven, commenting on DeHaven's "Miraculous Safety" article (76), and enclosing a sketch of his conception of an airplane "crash pad"

> "...consisting of a real shock-absorbing, air-filled cushion that could be inflated in a jiffy in any emergency. I conceived this as a cushion hidden in a moulding on the instrument panel, and of a U-shape; when inflated, it might form a cushion possibly a foot in diameter, and of course take care of some degree of rolling impact. The sketch attached may help. Along with this, there might be some special cabin design, some resilience built in to the entire structure, although that problem seems a harder one to crack."

Hugh DeHaven replied to Mr. Kotula, writing on May 7, 1941,

> "The sketch you enclosed showing an air or gas cushion is very much appreciated and may have valuable possibilities. ... There might be some danger in a protective means having rebound characteristics. I am sure you will be glad to hear that there is a recommendation going forward in the Civil Aeronautics Board which might lead to sponsorship of a study of injury causes and consideration of modifications which might help. Jerry Lederer is in back of the effort and I think it ought to get somewhere."

With the support of Jerry Lederer (77) and the CAB and U.S.Navy funding, and the support of Dr. Eugene DuBois, head of the Physiology Department of the Cornell Medical College in New York City, Hugh DeHaven in 1941 established in the Department the Cornell Crash Injury Project (78), and indeed "got somewhere" in showing the relation of vehicle design to crash injuries. But airbag crash pads were not developed. A few years later, the project split, with Aviation Safety Engineering and Research (AvSER) under Howard Hasbrook moving to Phoenix as a division of the Flight Safety Foundation and the Automotive Crash Injury Research program moving to the Cornell Aeronautical Laboratory in Buffalo, under John Moore. From 1947 - 1951, I was in the Physiology Department of the Cornell Medical College, doing graduate and post-graduate work in infrared spectroscopy and physiology under Dr. James D. Hardy and Dr. Eugene DuBois, but did not take up the study of Mr. DeHaven's work until some years later.

I too received a letter, in April, 1965, from an inventor, Donald W. Benrud, of Goodhue, Minnesota, who said that he had independently had the concept of airbag restraints for aircraft in the winter of 1960-61, fully documented and drawn up in April, 1961, but not patented. He attempted but failed to get support to make his system from G.T. Schjeldahl, maker of many of the high altitude balloons, and from the Aviation Crash Injury Research group of the Flight Safety Foundation. I had the good fortune to be at a company where I could do a certain amount of experimental work before having to get outside support...

Richard G. Snyder also reports (74) proposing to the Air Force in 1957 a personnel restraint system incorporating an air inflation system.

Assen Jordanoff, in 1956, made a presentation to the Flight Safety Foundation in which he ran against a wall in a chest/head airbag made to his design by the U.S. Rubber Company, and urged airbag restraints in aviation (64, 77). No further experimentation was done with this system. After Jerry Lederer told me about Jordanoff's work in 1964, I got to know Mr. Jordanoff, a pilot, aviation systems inventor and writer who had been an ace in the Bulgarian Air Force in the Balkan War of 1912. He gave me an unpublished diagram of his commercial aircraft airbag restraint design, dated March, 1952 (64), which antedates Hetrick's patent application, although Hetrick's concept may have been sooner.

The early work of the automobile companies was not published. Stuart Frey, Chief Body Engineer, Ford Motor Company, in 1970, presented a "History of Air Bag Development" (71). He notes a formal Ford airbag design study dated January, 1957, inflation tests in 1957, and a series of studies in the late 1950's and early 1960's. These were all unpublished. He states,

> "...no real progress could be made until the two key problems of sensor function and bag deployment could be resolved. In addition, it was believed that public acceptance would make unnecessary the adoption of a system as complex, and unproven as an automatic air bag restraint system."

It would have helped if the Ford work had been published.

In 1964, I was approached by a representative of the Eaton Corporation, to whom I presented all our data, which the Martin Company had agreed was public. I understand that Peter Haas, of Eaton, independently invented airbag restraints. Eaton, Yale, and Towne work on inflatable occupant restraint systems (79) began in 1964, with an Auto-Ceptor Division being formed in 1968 for application engineering and production studies. Eaton, Yale and Towne tested a pre-inflated pneumatic restraint system in April, 1966. Eaton and Ford established a cooperative joint research program on airbags in 1966 (80). In 1967, rapid inflation from a high pressure tank was demonstrated, and 42 High G sled tests and one barrier crash test (Ford's first automobile airbag test?) were carried out (80). The 1970 International Conference on Passive Restraints (see reference 71) notes other American and Japanese automobile company airbag work, but with no clear statement of human or dummy airbag crash tests prior to my work. The report by R.D. Lister at the First (1971) Experimental Safety Vehicle Conference (23) presented the passive belt concept, subsequently developed by Volkswagen.

The New York State legislature, under the leadership of State Senator Edward Speno, established the New York State Safety Car Program in 1965, the first governmental attempt to design safer passenger cars. The program was directed by John Moore, with major input from Henry Wakeland as a consultant. After a Phase 1 Feasibility Study, the program proceeded in 1966 - 67 to a Phase 2 Design and Development Study, with Republic Aviation as the contractor (81). In the fall of 1966, I was approached to be a consultant to this program, but arrangements could not be worked out with the Martin Company. I supplied our data. The study considers airbag protection, but opted for seat attached shoulder belts and lap belt.

The National Highway Safety Agency, of the Department of Commerce, and a sister agency, were established by the National Traffic and Motor Vehicle Safety Act of 1966 (P.L. 89 - 563, September 9, 1966, 15 USC 1381). This became on April 1, 1967, the National Highway Safety Bureau of the Federal Highway Administration of the new Department of Transportation, then on December 31, 1970, became the separate National Highway Traffic Safety Administration.

The four volume final report of the "Safety Sedan" study was turned over by New York State to the NHSB, in November, 1967. This led in 1968 to the establishment of the NHSB Experimental Safety Vehicle (ESV) Program (23), with major U.S. and foreign governments, and U.S. and foreign automobile manufacturers, developments of vehicles with significantly improved safety designs in comparison to vehicle then on the road.

NHSB staff studies (82), and support of the Air Force human and baboon studies (73, 74) confirmed the promise of airbag protection systems, particularly in connection with other vehicle improvements. On July 2, 1969 (34 FR 11148, Docket 69-07, Notice 1), NHSB published an Advanced Notice of Proposed Rule Making (ANPRM) proposing a regulation that the automobile manufacturers provide "passive restraint," or protection without occupant action such as having to fasten a seat belt, in 30 mph barrier crashes. Airbags were the most promising of means to meet the proposed standard conditions, although a variety of net, pad, "security blanket," and belt schemes were also being developed.

On May 7, 1970 (35 FR 7187, Docket 69-07, Notice 4), a Notice of Proposed Rule Making (NPRM), proposed a regulation requiring passive or automatic restraints in passenger cars after December 31, 1972. (See reference 29 for a detailed history of passive restraint regulations, with additional references). This Notice proposed a dynamic testing of the protective system by a frontal or oblique crash at 30 mph, a lateral crash into a fixed barrier at 15 mph, and a rollover. The Notice would allow passive restraints after January 1, 1972, but not require them, in the front and back seats, until January 1, 1973.

The Final Rule amending FMVSS 208 was issued on November 3, 1970 (35 FR 16937, Docket 69-07, Notice 7), then modified on March 10, 1971 (36 FR 4600, Docket 69-07, Notice 14), with acceleration criteria using dummies specified for the required injury protection, with the mandatory date for front seat passive restraints with a lap belt shifted to August 15, 1973, and for front and rear seating positions in all impact modes including the side impact to August 15, 1975. Chrysler and others sued DOT regarding the validity of the standard, The Department was upheld by the Court of Appeals in 1972 in its right to issue the standard, but the standard was set aside because of variability in dummy responses in repeated crashes. Dummy improvements were subsequently made, and by Rule Making action manufacturers were allowed but not required to provide passive restraints.

In this period, the Cumulative Regulatory Effects on the Cost of Automotive Transportation (RECAT) Committee was established by the Office of Science and Technology of the Office of the President (83). This Committee, with a "neutral" staff not involved in transportation safety mainly from the Naval Research Laboratory, emphasized the cost-benefit approach to safety regulation, questioned the pollution control plans, the use of airbags in the rear of a car as well as the front (which were in the government and industry ESV designs (23) and in FMVSS 208 up until then, and urged encouragement of belt improvements in comfort and convenience and of their use by the public as a less expensive alternate than airbags.

In the period from 1972-76, some 12,000 cars with front seat airbags were put on the roads. Road accidents involving these cars have been reported in a series of reports (84).

After an NPRM (41 FR 24070, June 14, 1976, Docket 74-14) and a public meeting on how to proceed with occupant protection, in January, 1977, Secretary of Transportation Coleman contracted with the automobile manufacturers for a "Demonstration Program" to produce up to 250,000 automatic restraint vehicles, half with full front seat airbags and half with driver only automatic protection, in each of the model years 1980 and 1981, to further introduce these restraint devices to the public. GM and Ford agreed to produce 60,000 airbag vehicles; Volkswagen agreed to produce 125,000 passive belt automobiles between 1975 and 1980. The states were also encouraged to pass mandatory belt use laws, although none did so. The demonstration program contracts had the stipulation that the contracts could be cancelled if passive restraints were again mandated.

With the new administration in 1977 desiring a more rapid introduction of passive restraints, a mandatory passive restraint regulation was published (27). The passive restraint would require testing with a 30 mph frontal or oblique fixed barrier crash, a side impact from a moving barrier simulating the front of a car at 20 mph, and a rollover at 30 mph.

The Demonstration contracts were cancelled, although Volkswagen continued to produce automatic belt cars. By this time, the other automobile manufacturers also had shifted their emphasis from airbags to automatic belts. The more recent regulatory picture of automatic restraints is presented above under belts for adults, at the bottom of page 6.

A definitive history of airbag restraints, covering as much of the automobile company propriatary work as can be released, and extending to the present is needed. The practical engineering work of the auto companies and their suppliers has been essential to airbag system development. My regret is that it has taken so long to get a system of frontal airbags with a lap belt which provides the best overall protection of car occupants in a crash (30 - Regulatory Analysis, page 2, restraint effectivenesses) available to the public. Some 13,000 Mercedes Benz airbag "Supplemental Restraint System" cars have been sold world wide in the last three years; driver airbag models are now (1984 model year) available in the United States. The present "2 inch" lap/shoulder belts become less adequate above 30 mph. Airbag systems can provide the broad load distribution to offer promise of greater protection above 30 mph. But how soon airbags will be widely available will depend on public and political pressures.

The automotive industry, in promoting belts, stresses that airbags do not protect in side impacts or rollovers. Instead, they should say that airbag systems for production automobiles have been designed for frontal impacts only. Ideally, controlled deformation materials - airbags or airseat - would be in all directions about the occupants in a crash, to prevent injurious contacts. I feel that further work on side impact airbags is needed.

Design Criteria for Crash Protection for Children, the Elderly, and the Handicapped

Dr. William Haddon has summarized certain crash protection design criteria (8):

> "If you were shipping an expensive miniature porcelain doll - whether of an adult or a child - how would you prepare the shipment? Knowing that post office and express shipments at best may get rough handling and, at worst, very violent treatment (although not normally as violent as a car crash), you would:
>
> o Provide a package that was not only as crashworthy as necessary, but that also assured a substantial additional margin of protection - a package sturdy enough to resist penetration or bursting open on impact, yet with smooth, soft, energy managing material inside to reduce the forces of such an impact on the precious contents.
>
> o Restrain the doll - that is, hold it in place (with plastic foam, excelsior or similar material) - so that it would not be smashed about in the package in an impact.
>
> o Seal the box so that even were it dropped or thrown about violently in transit, the contents would be protected against ejection, and therefore against being smashed to pieces against the pavement or the shipping-room floor."

Your chance of being killed in your next car trip is of the order of one in a million, or of being killed by motor vehicle within your life span of the order of one in sixty. Hence, most people ignore these odds, and ignore crash safety planning. They read about perhaps only two or three of the one hundred and thirty people killed by motor vehicles in the United States each day. They do not like "restraint" occupant packaging, prefering to move about. (Inflated restraints have great promise here, in being out of the way when not needed). And they don't like to pay for safety devices, little realizing that the social cost of accidents (16) a share of which on average they already are paying (with no safety benefit) each year is of the same order of magnitude as the cost of new cars - that is, the social cost of accidents of a car over its use life is on average commensurate with its new cost.

Unfortunately for spending money on safety instead of cleaning up crashes, the costs of accidents are widely distributed and hence hidden; the cost of a new car is very directly seen by the buyer, who then doesn't like to pay $500. for another perhaps never used safety device... For example, it is estimated (30 - Regulatory analysis, p. III-25) that only 7 percent of new cars with airbags would have had the airbags deployed in a crash when the cars are scrapped or abandoned. Many people feel they don't need crash protection - until they are in a crash - and then they need it badly. In 1981, with some 106 million registered passenger cars, 12 million passenger car occupants were in police reported accidents, of which 2.3 million cars were in police reported tow-away accidents, with 2.6 million occupants reported as injured and 26,545 killed (85). The National Safety Council estimates that only about a third of the accidents are reported to the police, although the unreported ones are expectedly those with minor or no injuries or damage (86).

The General Motors performance critia for an ideal inflatable system are given in reference (87). The design criteria of a crash protection system I suggest are

1. A restraint system and vehicle that are comfortable and convenient to use in normal driving. The restraint system should be as unobstrusive as possible.
2. A vehicle that deforms under crash loads to minimize loads delivered to the occupant compartment, up to barrier, pole, rollover, or car to car frontal, side, or rear crashes at the legal speed limit. (It is recognized that even with vehicle changes, some crashes, involving perhaps 20 percent of those now killed, will be unsurvivable without additional road and environment changes, to prevent train or truck to car collisions, submersion, or being engulfed in flames. Divided traffic and one way traffic and improved traffic lane barriers can further improve these conditions. With present vehicle structures and restraints, about 30 percent of the passenger car occupant deaths involve unsurvivable conditions at the occupant position - mainly with penetration due to large trucks (30, Regulatory Analysis).

3. An occupant compartment volume that is not penetrated by outside objects under these crash conditions.
4. A restraint system that during a crash holds the occupants of all sizes and whatever initial position within the occupant compartment and away from each other and hard surfaces, using available motion with respect to the occupant compartment to reduce loads on the occupant. This requires allowing only small displacements of the occupant within the compartment when the compartment loads are small at the start of the crash, so that displacement can used for load relief when the compartment loads are high. Loads up to the speed limit crash conditions should be not only survivable, but also the goal should be that they are tolerated without injury.
5. Under the design crash conditions, neither the vehicle nor the restraint should produce environmental threats (excessive loads, toxic gases, excessive noise, flame or heat, etc.) for the occupants.
6. Escape from the restraint and from the vehicle should be easy.
7. The restraint system should have a factor of safety for loads in its construction, so that if the vehicle can be repaired for reuse after a crash, the restraint can also be repaired, as inexpensively as possible. If there is no crash until the very end of the expected useful life of the vehicle, the restraint system should still perform with its full capabilities, i.e., it should have a high reliability and effectiveness throughout the vehicle useful life.

It is my hypothesis that multi-layered, multicompartmented inflatable systems can provide the best restraint part of this crash protection system for children, the elderly, and the handicapped, with more or less of the system being inflated during normal driving depending on the magnitude of postural instability or the need to relax of the occupant.

Designs for Inflatable Compartmentalized Protection Systems

Hugh DeHaven, the "father" of crash protection studies, in the classic work indicating that humans could tolerate far greater crash loads if the loads were well distributed (88), reports human falls with moderate injury into soft dirt from 150 feet up. John Stapp (31) further analysed these and related cases. In one case, a 42 year old woman weighing 125 pounds fell 55 feet into packed garden earth, hitting at 54 feet/second (37 mph), with the earth indented 4 inches by her left side and back. The woman remained conscious and was uninjured, having experienced an average deceleration of 140 G, with a average loading of 13.3 pounds per square inch. Peak deceleration and pressure may have been considerably more than the "square wave" averages. Stapp (31) also discusses an airman whose parachute did not open in a 1200 foot drop, with his striking the snow on his back at free fall terminal velocity (which would be attained after a fall of 482 feet) of 178 ft./s (120 mph), penetrating into the snow/ice layers 3.5 feet. With an average deceleration of 140.5 G, he sustained fractures of the second lumber vertebra and clavicle, and a few bruises, but remained conscious.

I have summarized such data to say (59) that it is not acceleration that produces injury, but body distortion produced by the acceleration event. With proper support to minimize body distortion, acceleration tolerance is greatly increased. Best effects might be obtained by water immersion (59); airbag restraints with allowed motion in all directions appear to be the next best.

Hugh DeHaven, in recognition that many people are killed in crashes in which the vehicle occupant compartment is still intact, called these "survivable crashes" - which would be survived if people had protection against their impacts with the occupant compartment, which Indiana State Police Sergeant Elmer Paul (66) later called the "second collision." During the late 1930's and 1940's, Hugh DeHaven illustrated crash protection by dropping a fresh egg from up to ten feet onto three quarters of an inch of ensolite, a padding material, with someone catching the egg on its rebound. During my lectures in 1961, I developed a variation of this, dropping a "vehicle" table glass containing a fresh egg just barely floating on salt water, and kept from contact with the glass by a ring of cotton. A sheet of Saranwrap prevents the egg from splashing out of the breaking glass during rebound. On impact, the table glass breaks, but the egg is unbroken. It is body distortion (local loading), not acceleration, which is damaging in a crash. The water distributes the crash loads, reducing distortion. (Much later, I found that Mr. DeHaven had also considered water protection (76), although I have not heard of his demonstrating it). A well designed airbag system can distribute crash loads over the body surface almost as well as water for moderate loads, although blood gradient effects under high acceleration are not matched by air pressure but can be by water (59).

A problem with inflated restraints is that compressed gases are partially elastic, depending on turbulence, gas cooling, airbag wall stretching, etc. for their less than fully elastic rebound. In my early experimental airbag work (62), I compared crash sensations with and without airbag venting to reduce rebound. With rebound into other airbags with about 3 cycles per second resonance frequency, and with some two thirds of the energy dissipated in each cycle, I found that the "multiple face slaps" of the rebound were not a problem, and went forward with airbag system designs that did not use large vents to reduce rebound on the first cycle. In addition, my first airbag systems were for spacecraft and aircraft, in which longer duration multiple impact events are more likely than with automobile crashes. For the aircraft and the automobile, I proposed venting by valve opening some 5 seconds after the crash began.

When I did my first test platform swing crashes with airbags in an airplane seat, it was the discomfort during rebound from the frontal airbag of "bottoming" on hard structures of the airplane seat back that led us to design the more yielding "airseat" (63), which I feel should be in automobiles as well, since many injuries are produced by hard structures within seats, or by seat failures. Any surface that the body can hit should controllably deform at a load below that which can cause injury, over a distance long enough to safely dissipate the velocity of the body with respect to the surface.

More recently, I have devised a new method to reduce rebound from airbag systems (5), which is conceptually similar to having a ratchet on a spring, which allows spring compression, but prevents spring expansion. This methods consists of using one or more "flapper valves," sewn on three sides over wide vent holes connecting proximal and distal airbags. As the first (or proximal) airbag is compressed by body contact, the gases easily vent into the distal airbag (or several layers may be used). When the body displacement ceases, the now compressed gasses are prevented by the flapper valves from returning rapidly to the proximal airbag, largely eliminating rebound. This effect has not yet been experimentally demonstrated. However, "flapper valves" have been used (89) on aspirator airbags to allow compartment air to enter the airbag while it is being expanded on filling, with the valves closing to reduce this extra venting during airbag compression.

This method of rebound reduction by multiple compartment layers and flapper valves rather than by venting prevents inflation gasses from ejecting into the occupant compartment, so that other than totally benign inflation gases or reactions might be considered for use, although one needs to consider the probability of bag rupture in the crash.

An ideal airbag system for the elderly and the handicapped would easily open out for occupant entrance, including persons with casts or special braces, and would consist of multiple compartments which could be controlled in inflation to provide the support desired during normal (non-crash) transportation. The outer high pressure inflated structure is to provide a reaction surface for the inner low pressure airbags in contact with the body. For those with body discomforts, selective inflation could support the body in ways, perhaps changing with time, to minimize discomfort. Indeed, a message function could be built into the proximal airbags, which include inflated structures supporting the body weight. With appropriate space in the vehicle, such as a van or ambulance, the support system could be selectively inflated to allow the handicapped person, for example, to sit up or lie down. To fill the selected airbag compartments, I conceive of supply tanks filled with 80 psi filling station air, perhaps built into the wheel wells, for the more elaborate forms of such handicapped transport systems. For comfort, the airbags in contact above the body would be at perhaps two inches of water pressure (0.07 psig or 500 newtons/square meter), and those below the body at perhaps 5 inches of water pressure. This pressure is not uncomfortable, and indeed one can totally relax with such full body support.

In a crash, airbag compartments in any direction in which the body is being thrown would be inflated automatically, to a higher pressure if they are already inflated, or if space allows and the surrounding airbags are already inflated, the displacement of the body alone would pressurize the proximal airbag "below" the body (in the direction opposite to the vehicle acceleration). The use of multiple layers of airbag compartments has been experimentally developed only to the extent of my work, with coworkers, on the "airlitter"(70), but offers the promise during impact of providing a smooth transition from very low pressure (5 inches of water) to very high pressure (20 psi if needed), with the bottoming load of each compartment layer being the load with which the next layer would begin to compress. The face, for example, hitting a 20 psi airbag, could be injured, but if it first pushes through airbags initially at lower pressure, the proximal airbags would distribute the load, reducing injury.

Figure 1 is my crude sketch of the kind of inflatable crash protection system for handicapped children with which I would like to experiment. It would be rather like the "Totguard" restraint, but with the outer shell an inflated 5 psi structure rather than rigid plastic. Before pressurization, the structure could unzip down the middle, to let the child with any cast or brace be positioned in the system, which would then be closed over him. For road travel, there would be an initial pressurization of the high pressure "shell," and lower pressure airbags to support the body. In a crash, additional airbags would be inflated to expand up and cover the chest and support the head. Airbags on the sides of the head could be partially inflated to support the head of the cerebral palsey child, for example, during normal driving. Ideally, a cooling system, perhaps using the Peltier effect to cool electrically, would be used to provide occupant comfort. The shell would be secured on the car seat with a lap belt and possibly a top tether.

Figure 2 is my crude sketch of a possible wheelchair occupant/driver restraint system. The forward outer shell, inflated to perhaps 10 psi, is like the toe of a slipper into which the wheelchair is pushed. The wheelchair frame would have flat surfaces front and back (not shown) against which additional 10 psi airbags would be inflated to support the wheelchair weight during impact. Within the slipper shell, limited distension airbags would fill the interstices, with the proximal airbags (touching the body) at low pressure until impact. Behind the slipper shell, airbags would be inflated on entry, at high pressure to support the wheelchair frame and at lower pressure to support the wheelchair back. A low pressure airbag would be between the wheelchair back and the occupant, to reduce rebound discomforts in a crash. On impact, airbags would inflate to support the chest and head, and perhaps shoulders laterally. This system has not yet been built.

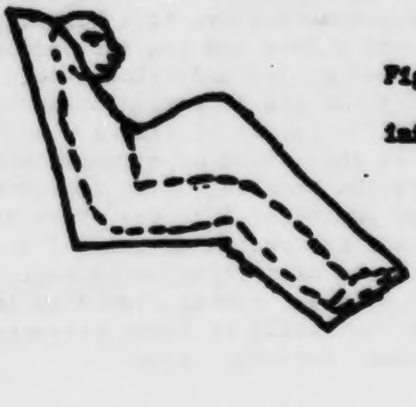

Figure 1: The handicapped child inflated protective system concept

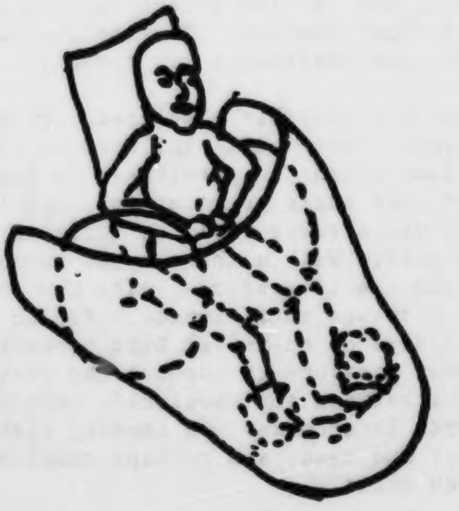

Figure 2: The wheelchair occupant protective system concept

It is the contention of some that airbags are too expensive to be cost beneficial for use in motor vehicles. Such cost-benefit analyses have been used to lower the nation's sights as to what percent of the crashing public should be saved by mandated protective systems. If everybody used present mandated systems, perhaps half of those who would have been killed without such systems (notably, belts) would be saved. I would like to see research go on for "saving the other half." I am convinced that the distributed load potential of airbags, and the biological tolerance for high crash loads if well distributed on the body, make airbags the way to save this other half, along with improvements in vehicle structure, means for crash avoidance such as radar brakes, and improved vehicle environments, such as more one way streets and isolation from crashing into trucks or trains . For certain populations, notably children, I feel that the public is ready to save them all, not just the "cost-effective" some in crashes, and that the research should be carried out to show how this might be done. Once the possibilities are demonstrated, I feel that means to cut the cost of airbag systems should be a significant part of the research.

It is however true that systems that are produced in only small numbers, as for the handicapped, tend to be more expensive. Many of the handicapped and elderly would get adequate protection from a standard lap/shoulder belt, particularly if augmented by an airbag. But clearly there will still be some number who cannot use these standard devices. For them, adequate protection devices can and should be developed. A measure of the ethical values of a society is not how it treats the average citizen but how it treats those not able to fully care for themselves.

Finally, it is interesting to consider whether technology that has been developed for motor vehicle transportation safety, such as the airbag, might have a broader application. One such application could be the problem that afflicts so many elderly people, that of breaking the hip in a fall. Dr. Louis V. Avioli reports (90) that some 200,000 people each year fall and break their hips, typically at the neck of the femur. Osteoporosis, the progressive demineralization of the bones of older people, and particularly of women, is often involved. Between 40,000 and 80,000 of these old people subsequently die due in significant part to the broken hip consequences. Baker, O'Neil and Karpf report (37) that 13,000 deaths per year of all ages are attributed on death certificates to falls, but note that the consequences of falls are significantly underreported as the cause of death (91). More than half of the deaths attributed to falls involve people 75 or older, who are about 4 percent of the population (37). Some 3.5 million person - hospital days are required annually to treat hip fractures of those 65 and older (92). This can be compared to the estimate (85) of 4.2 million person - hospital days for the treatment of all ages for the consequences of all motor vehicle accidents.

The standing height of the head of the femur is about half of the body height. Free fall from 2.5 feet under the 1 g of gravity involves contact in 390 milliseconds, with a velocity of 12.6 feet per second or 8.6 miles per hour. A femur head at 3 feet takes 430 milliseconds to impact at 9.4 mph. A fall while walking or getting out of bed is typically not a free fall; a partially supporting leg would lengthen the time to impact. We are aware that we are falling, and typically have time to put out an arm to catch ourselves, a process with a reaction time of a few hundred milliseconds. Airbag systems for automobiles have inflation times near 30 milliseconds - to get the airbag back to the person before significant forward motion on the seat has begun in the crash.

It would be possible to design sensors to trigger the inflation of a hip airbag through a combination of a detection of an acceleration of less than 0.5 Gz at the waist of more than 100 milliseconds duration, and a body "roll" or lateral rotation with respect to a horizontal plane of more than 45 degrees. (For body motion terminology, still not standardized in spite of earlier efforts, see reference 94). Hip airbags on each side about a foot long and six inches deep when inflated, attached at the waist and about each leg, could soften the impact of the fall.

The sensors could trigger the opening of a valve releasing compressed gas into a hip airbag. A small pressurized tank could provide a sufficient supply of gas. This tank would be connected to the valve prior to use, and easily replaced after use. The sensors, tank, and valve could be contained in a small unit worn on the waist. The valve would have a release control for deflating the airbags after inflation. Ideally, a hip airbag would be pressurized to such a level before impact that the impact load would be distributed over a much wider area than the femur, and would build up more slowly, to a lower force over a longer duration, perhaps with the femur barely "bottoming" through the airbag onto the floor, hopefully preventing the fracture.

The device could be worn under loose clothing, to allow unrestricted inflation. To reduce rebound, a hip airbag could contain two compartments, an outer compartment of perhaps 4 inches connected to an inner compartment of 2 inches through a large diameter "flapper valve" which allows gas to move rapidly from the outer compartment to the inner compartment during compression by hip contact, but does not allow gas to return rapidly to the outer compartment. Experimentation on the optimum configuration of the hip airbag obviously would be required.

Again, the purpose of this entire discussion is to encourage the application of well understood technical principles to a wide variety of situations that currently produce harm. Injuries that could be avoided by the application of this knowledge should not be accepted. Nor should we restrict our horizons to motor vehicle transportation safety if what we know might be of help in related fields.

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Each rule making action has associated with it a "docket" of public documents submitted by the government, companies, and individuals as to the advisability of the action. These are identified by a docket number or numbers associated with a given standard plus a document number. The NHTSA Docket Section, Room 5109, 400 Seventh Strret Southwest, Washington, DC 20590, may be visited to see these submitted documents in each docket, or may be written for a list, with copies obtainable at reproduction cost.

The standards and Parts discussed in this report are
Part 571, Federal Motor Vehicle Safety Standards
  FMVSS 201, Occupant protection in interior impact.
  FMVSS 208, Occupant crash protection.
  FMVSS 209, Seat belt assemblies.

4. (Continued)

FMVSS 210, Seat belt assembly anchorages. (Note that Section S4.1.1 requires that lap and shoulder belt anchorages be provided in all forward facing outboard seating positions, in passenger cars except convertibles - front or back. I encourage the public to ask the dealers for the locations of these rear seat shoulder belt anchorages, and install lap/shoulder belts in the outboard rear seats, for their greater protection than lap belts alone. This is particularly important for shoulder strap use by the 5 to 11 year old child using a booster seat for which the tether attachment for use of the child shoulder straps has not been made).

FMVSS 213, Child restraint systems.

FMVSS 222, School bus passenger seating and crash protection.

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IMPROVING THE PERFORMANCE OF TRANSPORTATION TO THE HANDICAPPED THROUGH USER-SIDE SUBSIDIES ; CALGARY'S EXPERIENCE

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INTRODUCTION

Two trends have recently dominated in the development of specialized door to door services for the elderly and handicapped in Canada. The first is the decision of municipalities to opt for contractual arrangements with private transit management companies and non-profit agencies rather than providing service as part of the regular transit system. A second trend is the predominance of vehicle systems dedicated solely to the provision of elderly and handicapped service.

The City of Calgary has been active for many years in the development of specialized transit services of the handicapped. In the early 1970's, Calgary became one of the first Canadian cities to introduce a door to door handibus service for persons unable to use regular public transit. In the intervening period Calgary has expanded the scope of its special services in a manner somewhat unique for Canada through the development of taxi-based systems for the ambulatory handicapped and the organization of service along user-side subsidy principles. This method of subsidization differs from the more traditional transit subsidies in that the users rather than the providers of transportation are subsidized. Persons eligible for the subsidy pay only a portion of the full fare for the trips taken via the selected transportation provider. The service operator is then reimbursed for the remainder of the fare by the subsidizing agency.

This paper will draw upon performance reviews and user surveys undertaken in Calgary to outline how the special handibus and subsidized taxi programs have been developed and subsequently modified in an attempt to improve the overall cost efficiency and effectiveness of service delivery. Emphasis will be placed on the applicability of taxi based services and user-side subsidy principles to elderly and handicapped transportation, drawing upon historical data and recent experiments which integrated taxi and special van services. The paper concludes with a review of the applicability of Calgary's experience to other jurisdictions.

CALGARY CONTEXT

Calgary is situated in the foothills of the Rocky Mountains in Western Canada and is the "capital city" for Canada's petroleum industry as well as a major agricultural centre. In 1983, the City population was approximately 623,000 and was encompassed with an area of approximately 510 sq. km.

On the basis of information obtained from recent interview surveys of disabled organizations and institutions, it is estimated that there are a minimum of 17,500 mobility limited disabled persons residing in Calgary of which 14,300 persons (2.4 percent of the population) are unable to use regular public transportation and 3,200 persons (0.5 percent of the population) can use it but with much difficulty. Although the estimate of 17,500 mobility limited disabled persons represents a measure of the market for specialized transit services, it has been demonstrated that the mobility requirements of disabled persons vary significantly depending upon the nature of their functional limitation. For example, in Calgary, it is estimated, based on agency surveys that only one quarter of the mobility limited disabled (3,600 persons) are wheelchairbound and require specially modified vehicles and special assistance in travelling within the City. The remainder of this group (approximately 10,600 persons) are ambulatory and are physically able to be transported in a regular automobile such as a taxi.

Travel behaviour data obtained from surveys of disabled population in Calgary indicate that although a large number of private and public agencies are participating in the delivery of transportation service, the City funded handibus and subsidized taxi services are clearly the dominant modes of travel used by the transportation handicapped. Present trends indicate that Calgary's disabled population make about 50 percent less non-work trips and 85 percent less work trips than the general population.

Population projections for Calgary to the year 2000 indicate that population of the elderly (over 65) age group will more than double. Since the incidence of disability has been found to increase with age, it is expected that there will be continued strong demand for specialized handibus and taxi services. These facts also suggest that it will become increasingly important to maximize cost-effectiveness in the delivery of transportation services to this segment of the population.

Handibus and Subsidized Taxi Program Description

Calgary's handibus and subsidized taxi programs have historically performed unique roles in accommodating the urban travel requirements of the City's elderly and handicapped population. A brief summary of the background and characteristics of these services is useful as an aid to understanding the rationale for recent service modifications.

Handibus - The City funded handibus service provides dedicated subscription, charter and demand responsive service to disabled Calgarians who are unable to use regular public transportation with dignity or without assistance. The program is administered and operated by Calgary Handibus Association, which is an independent, non-profit organization registered under the Alberta Societies Act.

The recent development of the handibus service has been significantly influenced by controversy and debate on the relative merits of rail transit (LRT) accessibility versus specialized parallel transportation. Although Calgary City Council decided in 1979 that it would be inappropriate to make the initial leg of LRT fully accessible to the handicapped, the ensuing debate did lead to the adoption of a policy objective that service on handibus become a one hour response time, seven days a week, 6:00 a.m. to 1:30 a.m. This decision has resulted in a dramatic increase in service patronage and the level of operating subsidies provided by the City of Calgary (see Exhibits 1 and 2).

EXHIBITS 1,2,& 3

EXHIBIT 1 HANDIBUS AND SUBSIDIZED TAXI SERVICE ANNUAL BUDGET, 1975 - 1983

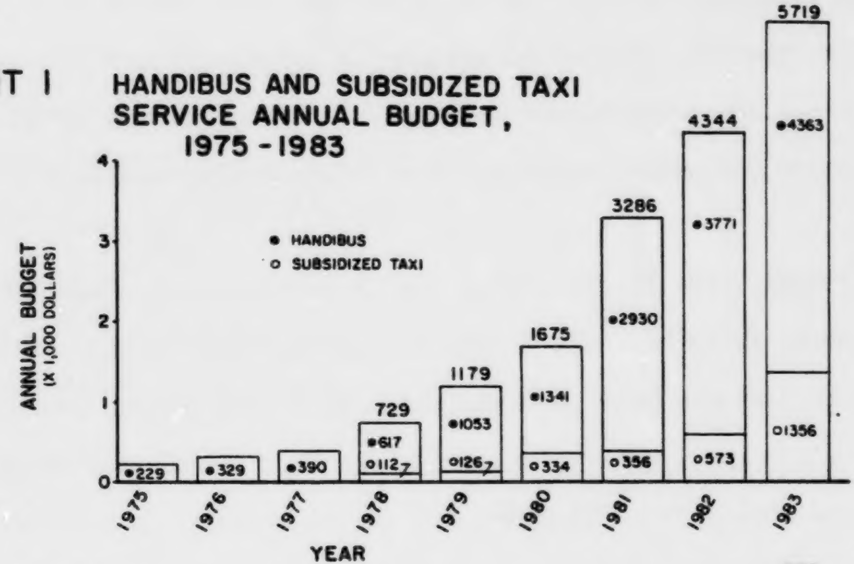


EXHIBIT 2 HANDIBUS AND SUBSIDIZED TAXI SERVICE PATRONAGE DATA 1975 - 1983

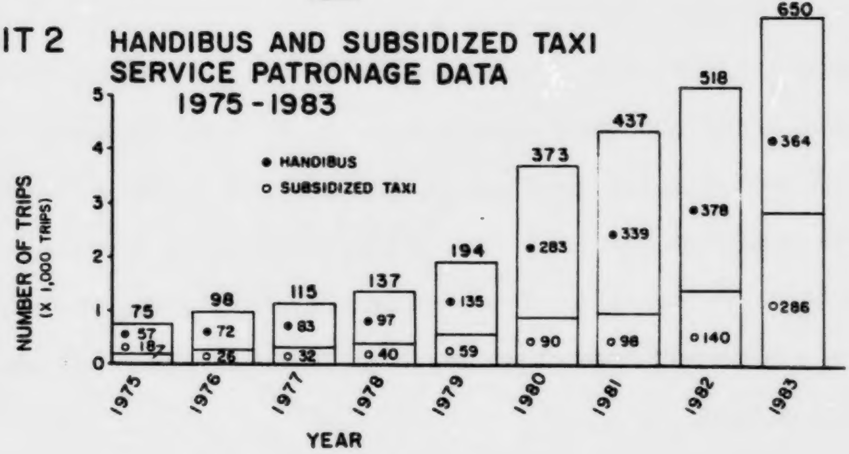
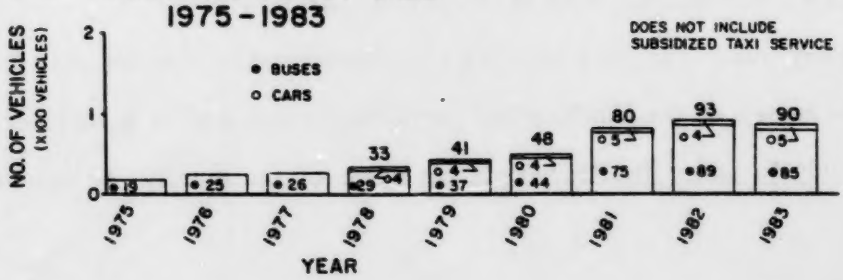


EXHIBIT 3 HANDIBUS FLEET SIZE 1975 - 1983



Expansion has also been aided by donations of buses and major equipment items by various clubs, organizations and individuals (see Exhibit 3).

Until recently, eligibility criteria for handibus were defined according to age and type of disability. Service was available to the wheelchairbound regardless of age and to the ambulatory disabled under age 65. Persons reaching age 65 who were not confined to a wheelchair were transferred to the subsidized taxi program.

Subsidized Taxi - The City subsidized taxi program employs a user-side subsidy concept which allows handicapped users to purchase trips from commercial taxi operators at fares well below those charged to the general public. This service was initiated in 1974 and is presently operated by eight taxi companies under contract to the Handibus Association. Historical data on the annual budget and ridership is summarized on Exhibits 1 and 2.

Prior to the institution of recent service charges, the subsidized taxi service was available to the ambulatory disabled over age 65, upon submission of medical certification confirming the applicant was physically unable to use regular transit with dignity or without assistance. The program provided for a maximum monthly subsidy of $45.00 in taxi fares. This allowance covered the sum of all taxi meter charges less a 10 percent discount per trip (borne by the taxi operator) less the one-way trip fare of $1.50.

HANDIBUS AND SUBSIDIZED TAXI OPERATIONAL REVIEW

In early 1981, the City of Calgary Transportation Department initiated a operational review of the handibus and subsidized taxi programs in conjunction with a broader study to assess the transportation needs of the elderly and handicapped in Calgary.

The objectives of the handibus and subsidized taxi review were two-fold:

(a) to evaluate how well actual service provided accommodates existing and projected travel demand.

(b) to assess the need for policy and procedural changes to improve service efficiency and affectiveness.

Operating and financial data were utilized as criteria for assessing system efficiency and effectiveness. As well, the input of user groups and other spokespersons for the disabled community were actively sought through a major questionnaire survey of 12,000 disabled persons and interviews with approximately 40 agencies serving the elderly and handicapped in Calgary. The following points summarize the major findings of this review.

Service Effectiveness

- It was determined that handibus was providing a high level of service to program users and achieving the City approved objective for 1 hour demand-response service. On demand service comprised approximately 62 percent of all weekday trips compared with approximately 34 percent subscription travel and 4 percent for charter service. Service refusals averaged only 1 percent of total daily ridership on a typical weekday and 5 percent on weekends.
- overall utilization routes for both the handibus and subsidized taxi programs were observed to be quite low despite an average monthly increase in registration of 100 and 200 persons respectively. Fewer than 50 percent of registered users typically made use of the services in any given month. The average number of one-way trips per person was approximately 4 per month for the subsidized taxi service and 10 per month for handibus.
- Input received through the questionnaire and personal interview surveys confirmed that there was a significant level of user satisfaction with both programs. Sixty-eight percent of questionnaire respondents rated handibus

service as commendable or satisfactory while 83 percent gave a similar rating to subsidized taxi.

Service Efficiency

- Based on the cost and performance trend data in Tables 1 and 2, it is apparent that the handibus service has maintained low levels of productivity as reflected by the number of one-way trips accommodated per vehicle hour. Considerations which contribute to the relatively low vehicle load factors include:

  (i) long average trip lengths (10.1 km) and heavy levels of congestion on major roadway arterials during peak travel periods,

  (ii) the relatively high proportion of "unpredictable" on demand trips (63 percent),

  (iii) the highly personalized nature of the service, often requiring provision of assistance from the driver within buildings at the trip origin and destination,

- The average cost per trip for the subsidized taxi program has remained below that recorded by handibus. The lower cost of the taxi service is attributable to:

  (i) shorter distances for taxi trips compared with handibus. This possibly reflects a user awareness of the subsidy limit provisions of this program.

  (ii) higher user fares for subsidized taxi travel ($1.50/trip compared with $0.90 for handibus).

  (iii) inherent efficiencies in user-side subsidy principles. One of the main advantages of this approach over dedicated, fixed capacity systems such as handibus is that the funding agency pays only for the quantity of service consumed. This protects the funding agency from having to pay for unused service or capacity during periods of low travel demand.

TABLES 1 AND 2

TABLE 1

Calgary Handibus Service
Cost/Productivity Summary, 1978 - 1982

	1978	1979	1980	1981	1982
Operating Costs	$880,798	$1,358,091	$1,803,946	$2,929,529	$3,771,376
Number of Km operated	1,655,857	2,239,171	2,510,375	3,332,825	3,852,569
Number of trips/ day	536	702	774	930	1,174
Number of trips/ vehicle hour	N/A	N/A	N/A	1.6	1.9
Cost/trip	$4.50	$5.30	$6.67	$8.63	$9.98
Subsidy/trip	$3.75	$4.55	$5.92	$7.88	$9.08
Cancellation Rate	32%	1-2%	1-2%	1-2%	1-2%
Fare	75¢	75¢	75¢	75¢	90¢
% Operating Cost recovery from fare box	16%	15%	10%	7%	9%
Fleet size	37	48	51	80	93

TABLE 2

Subsidized Taxi Service
Cost/Patronage Summary, 1978 - 1982

	1978	1979	1980	1981	1982
Operating Cost	$99,148	$164,342	$306,709	$355,539	$572,999
Number of Trips	39,898	58,708	90,301	98,020	140,264
Average Cost/Trip	$3.99	$4.30	$4.90	$5.12	$5.59
Subsidy/Trip	$2.49	$2.80	$3.40	$3.62	$4.09
Average Number of Trips/Person Monthly	4	4	3.9	3.7	4

IDENTIFICATION OF IMPROVEMENT OPTIONS

The results of the user surveys and the operational review demonstrated that latent demand for the handibus and subsidized taxi services was relatively low. Despite these findings, an evaluation was undertaken to assess the cost-effectiveness of service delivery in light of anticipated travel demand by the disabled. It was concluded that although it would be feasible to continue expanding the handibus service to accommodate both the ambulatory and non-ambulatory segments of the market, a more cost-effective approach would be to transfer ambulatory handibus users to a subsidized, taxi based service.

Issues

Potential issues anticipated with the above proposal were the more restrictive travel limitations and higher user fares associated with the taxi program, as well as the need to accommodate group trips involving wheelchairbound and ambulatory users, originating from nursing homes and auxiliary hospitals. To address these concerns, the following provisions were incorporated to make the two programs more compatible:

- The decision was made to transfer only the on-demand service for the ambulatory disabled to the taxi industry, thus retaining regular subscription service as a responsibility of Handibus. This would allow the operator to continue to assign subscription trips as routes to handibus vehicles, thereby maintaining reasonable vehicle load factors and making maximum use of available service capacity.
- Handibus would continue to provide transportation for group trips originating from nursing homes and auxiliary hospitals.
- User fares for the handibus and subsidized taxi services were established at a similar level for a six month trial period. This had the effect of reducing the user fare for the subsidized taxi service from \$1.50 to \$0.90 per one-way trip.

- The monthly subsidy level for the taxi program was increased from $45.00 to $70.00, also on a six month trial basis. This level was calculated to allow the potential for approximately ten one-way trips of a 10 km distance, which was equivalent to the average trip length and number of monthly trips taken by handibus users.

Anticipated Benefits

The increased emphasis on taxi based elderly and handicapped service was expected to offer the following benefits:

- Reduce the rate of growth in demand and operating costs for the handibus service by maximizing the use of lower cost, taxi based services.
- Improve travel opportunities for existing and new subsidized taxi users through increased subsidy limits and a greater selection of service providers from which to choose.
- Improve service for wheelchair users of handibus. This segment of the population have a greater need of the special vehicles and custom services provided by the Handibuses Association than the ambulatory disabled who, in most cases, could be transported in a regular automobile with limited assistance.

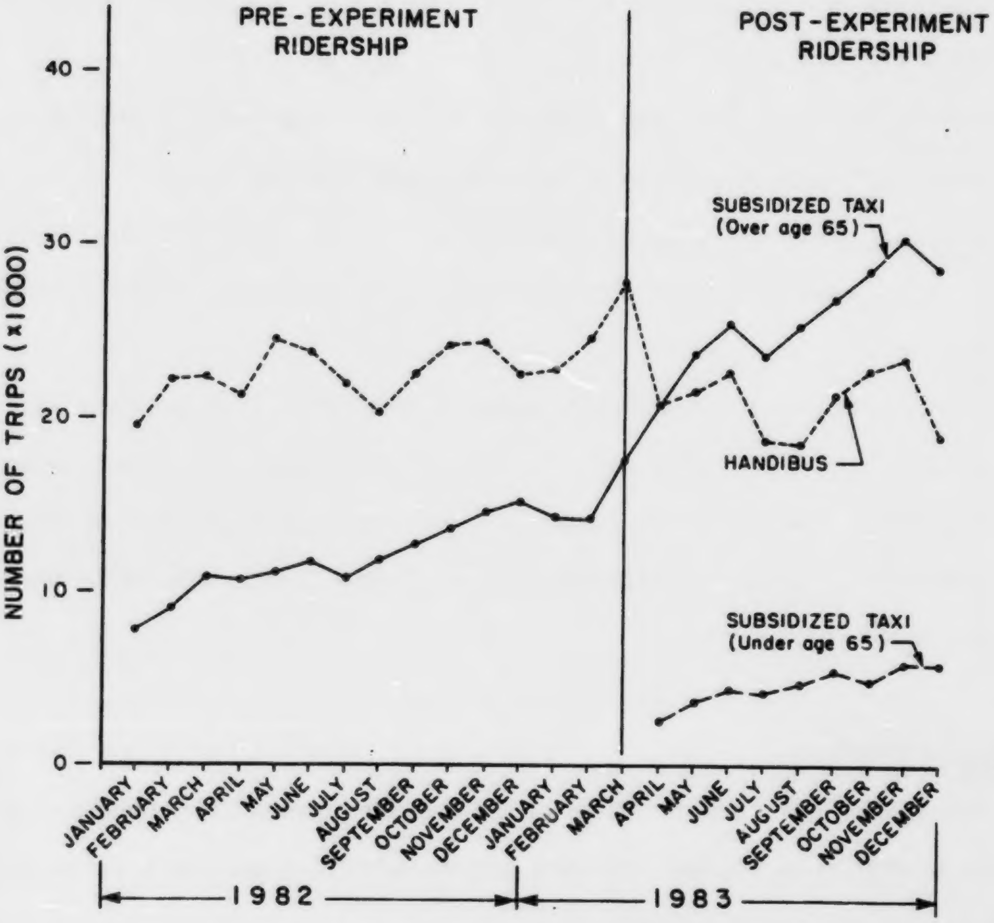
Experiment Results

This section examines the effect of the transfer of ambulatory handibus users and the institution of revised taxi fare and subsidy limit provisions on program ridership, user satisfaction and costs.

Ridership - As expected, the changes in structure of the handibus and subsidized taxi program improved travel opportunities, which resulted in increased usage by patrons of both services. In the handibus service, there was a decrease in the number of users

EXHIBIT 4

HANDIBUS AND SUBSIDIZED TAXI RIDERSHIP BEFORE AND AFTER EXPERIMENT



per month due to the transfer of ambulatory users to the subsidized taxi service but an increase in the number of average monthly trips per user from approximately 10 to 18. As noted in Exhibit 4, there was no significant change in total monthly trips delivered by the program.

In the subsidized taxi program, the most dramatic increase in ridership was observed among the elderly (over 65) age group who previously used the program. Average monthly usage increased only slightly from approximately 4 trips per user to approximately 5.5 trips per user. The rate of new registration however, increased dramatically from an average of 200 users per month to 300 users per month. The result was a rapid increase in total trips delivered under this component of the program (see Exhibit 4). By contrast, the growth in the under 65 age component of the program was more moderate, despite a higher usage rate of 8.5 trips per user per month.

User Satisfaction - User surveys conducted after the introduction of the new taxi fare and subsidy structure indicated a very favourable attitude toward the program among the elderly age group, no doubt resulting from the more generous program provisions. In the under 65 age group, it is significant that the majority of users found the taxi program to be generally more satisfactory and responsive to their travel needs than handibus, perhaps due to improved availability of transportation and the variety of transportation providers involved in this program.

Costs - As a result of the lower taxi fares and higher subsidy limits, the average cost of the subsidized taxi service increased during the term of the experiment from $4.02 to $4.74 per trip. When compared against the average trip cost of $12.25 for handibus, it is evident that there were economic advantages to transferring on demand service for ambulatory handibus users to the subsidized taxi program. These benefits however, were overshadowed by the rapid growth in ridership and costs in the elderly (over age 65) component of the taxi program which occured after the fare and subsidy modifications. The total program cost increased from the pre-experiment level of $573,000 in 1982 to $1.6 million in 1983. A further escalation to $2.5 million in 1984 was projected if current usage trends continued. When faced with this situation and the risk of continued cost increases on the same magnitude, City Council directed that the following steps be taken to curtail service growth:

(a) introduction of more specific medical eligibility criteria.
(b) introduction of a sliding subsidy limit based on income.
(c) introduction of annual renewal of user identification cards.
(d) limits on the number of taxi cards to one per family.

These program modifications are expected to reduce total program costs from $2.5 million to $2.1 million in 1984.

CONCLUSIONS/TRANSFERABLE LESSONS

On balance, the City of Calgary's experience has demonstrated that taxi based systems employing user-side subsidies can provide a very attractive method of delivering effective, low cost transportation to the elderly and handicapped market. The significant conclusions from Calgary's experience with this type of program are summarized below:

- the cost to the public to subsidize a taxi trip through a user-side subsidy program is substantially less than the average per trip cost of dedicated fixed capacity systems such as handibus.
- the high cost of specialized taxi and handibus operations relative to regular mass transit suggests that attention should be paid to carefully defining program eligibility in order that financial resources be directed to persons most likely to need special transportation. Many handicapped and elderly individuals

may not necessarily need special transportation services because they are automobile drivers, have someone to drive them or are able to use regular fixed route transit.

- taxi based transportation appears to have the greatest applicability to the ambulatory segment of the handicapped market, typically comprised of persons with relatively minor mobility limitations. The use of commercial taxi carriers to accommodate these persons allows handibus operators to direct their service to the non-ambulant, wheelchair market who have a greater need for specialized vehicles and assistance.
- taxi services have been well received by elderly and handicapped target groups. The taxi industry in Calgary has also been very supportive of the program and are willing to absorb small subsidy and administrative costs in return for the expectation of increased business. It should be noted, however, that support extends primarily to the ambulatory and elderly segment of the handicapped market. Although most taxi companies will accept trip bookings from the wheelchairbound, a majority have indicated that they are not keen to encourage a greater level of patronage from this segment of the population.
- There is no evidence to suggest that the quality of service provided by taxi operators is any different for subsidized or non-subsidized users. On the contrary, taxi operators have demonstrated a willingness to provide special attention at no additional charge to the user.

In conclusion, Calgary's experience demonstrates that taxi based user-side subsidy programs have a potentially valuable role to play in handicapped transportation either as a complement to dedicated paratransit operations or as a separate, freestanding program. Two of the inherent advantages of the concept are its flexibility and cost efficiency, factors which allow it to be applied to urban centres with widely different population characteristics and financial resources.

COST-EFFECTIVE DATA COLLECTION PROCESS TO SUPORT TRANSPORTATION PLANNING FOR TRANSPORTATION-HANDICAPPED PEOPLE

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ABSTRACT

COST-EFFECTIVE DATA COLLECTION PROCESS TO SUPPORT TRANSPORTATION PLANNING FOR TRANSPORTATION-HANDICAPPED PEOPLE

This paper highlights the results of five years of continuous research into the methods used by transportation planners, local agencies, and transit operators to collect data on the travel characteristics and needs of transportation-handicapped people. The research effort focused on primary, secondary, and self-identification data collection techniques for identifying and developing information on transportation-handicapped people. As a result of this research, a comprehensive and cost-effective data collection process evolved for use in developing information on the incidence rates, characteristics, geographic location, travel habits, and transportation problems and needs of transportation-handicapped people at the local level. This process consists of the following techniques:

- Areawide Telephone Survey - of a sample of transportation-handicapped people through use of a screening survey, in-depth handicapped person questionnaire, and travel diary.
- Census Data Factoring of Areawide Telephone Survey Data - to disaggregate the areawide data to the subarea level of detail.
- Small Subgroup Survey - of specialized subgroups of the transportation-handicapped population through social service agency assistance.
- Ongoing Service Monitoring - through registration files, periodic on-board counts, and service requests and inquiries.

The paper outlines the nature and purpose of the techniques making up the recommended data collection process, as well as the general steps and costs associated with their development and implementation.

COST-EFFECTIVE DATA COLLECTION PROCESS TO SUPPORT TRANSPORTATION PLANNING FOR TRANSPORTATION-HANDICAPPED PEOPLE

This paper briefly describes a data collection process for use by local transportation planning agencies and transit operators in planning, designing, and evaluating public transportation services and facilities for use by transportation-handicapped people. It is based on an extensive five-year research effort, conducted by Peat, Marwick, Mitchell, & Co. for the Urban Mass Transportation Administration, which assessed various methods of collecting data concerning the composition and transportation needs of transportation-handicapped people. The resulting process consists of several data collection techniques which together address the following issues:

- What is the size of the transportation-handicapped population within a local area?
- What are the characteristics of the local transportation-handicapped population in terms of disability, geographic distribution, and transportation needs?
- What are the travel habits of the local transportation-handicapped population?
- How effective are current public transportation services and facilities in serving transportation-handicapped people's needs?

BACKGROUND

In 1970 Congress amended the Urban Mass Transportation Act of 1964 to declare as a national policy that "elderly and handicapped persons have the same right as other persons to utilize mass transportation facilities and services." Congress also authorized the Secretary of Transportation to require that special efforts be exerted in the planning of mass transportation facilities and services to ensure that they could be used effectively by elderly and handicapped persons.

The "special efforts" requirement was eventually incorporated into the urban transportation planning process in September 1975 when the Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA) jointly issued regulations requiring that special efforts be made to make mass transportation facilities and services useful to elderly and handicapped persons. These regulations also made federal funding of local transit operating and capital programs contingent upon compliance with the "special efforts" requirement. These regulations were subsequently expanded and clarified in April 1976 when UMTA and FHWA issued guidelines advising transportation planners to rely on existing sources of data as much as possible to obtain information on the location and transportation needs of elderly and handicapped persons, particularly wheelchair users and semi-ambulatory handicapped persons. UMTA and FHWA also suggested that planners use self-identification techniques rather than elaborate survey methods to locate transportation-handicapped persons.

Initial attempts by state and local planning agencies to obtain usable data on the location and transportation needs of elderly and handicapped persons from existing sources and self-identification techniques were not very successful. Although there were many secondary sources of information about the nature and travel characteristics of elderly and handicapped people, each source had numerous limitations. No single existing source or combination of sources provided complete, accurate, and reliable information on elderly and handicapped people living in urbanized areas. In addition, self-identification survey techniques proved inadequate either for developing representative samples of elderly and handicapped people or for locating a large sample quickly.

The limitations of these data collection techniques prompted UMTA to study alternative methods of collecting information on the transportation-handicapped portion of the elderly and handicapped population. UMTA considered various methods, including:

- primary data collection;
- use of secondary data sources; and
- use of self-identification survey techniques.

Exhibit 1 summarizes the major techniques associated with each of these data collection methods, while Exhibit 2 compares the three methods relative to several evaluation criteria.

After reviewing and testing various data collection methods in a series of demonstration projects, UMTA selected several techniques which together provide a comprehensive data collection process for use in local planning for the transportation needs of transportation-handicapped people.

ELEMENTS OF THE DATA COLLECTION PROCESS

The data collection process for developing information on the transportation-handicapped population of a local area consists of three interrelated elements, each of which represents a separate technique or group of techniques, and a fourth element for continued service monitoring. Multiple techniques are used because no one technique can effectively and efficiently provide all the information needed for properly planning for the needs of transportation-handicapped people.

The first three elements of the data collection process provide increasingly detailed information regarding the number, characteristics, and

EXHIBIT 1

DATA COLLECTION METHODS FOR TRANSPORTATION-HANDICAPPED PLANNING

PRIMARY DATA COLLECTION

- Home Interviews
- Telephone Interviews
- Mail Surveys
- Trip Diary
- Field Observations
- On-Board Surveys
- Passenger Counts
- Focus Panels
- Product Testing Techniques

SELF-IDENTIFICATION SURVEY TECHNIQUES

- Self-Administered Mailback Questionnaires
- Self-Initiated Telephone Responses
- Personal Interview at Designated Location
- Registration for Special Programs

SECONDARY DATA SOURCES

- Census of Population and Housing
- Health Interview Survey
- Social Service Agencies
- Private Service or Membership Organizations
- Local Transportation Studies
- Registration Files
- UMTA National Survey of Transportation Handicapped People

EXHIBIT 2

COMPARISON OF DATA COLLECTION METHODS FOR TRANSPORTATION-HANDICAPPED PLANNING

EVALUATION CRITERIA	PRIMARY DATA COLLECTION	SELF-IDENTIFICATION SURVEY TECHNIQUES	SECONDARY DATA SOURCES
Amount and Variety of Data	Extensive	Limited	Variable
Accuracy	High	Low	Variable
Representativeness	High	Low	Variable
Coverage	High	Low	Variable
Response Rate	Moderate	Low	Not Applicable
Time Required	Moderate	High	Low
Cost	Moderate to High	Low	Low
Potential Restrictions	Few	Many	Variable
Currentness	High	High	Variable

needs of the local transportation-handicapped population. This information is used primarily for developing new services or service changes. These three interrelated elements are:

- Areawide Telephone Survey - to establish the overall size, characteristics, travel habits, and transportation needs of the local transportation-handicapped population.
- Census Data Factoring of Areawide Telephone Survey Data - to estimate the geographic distribution of the local transportation-handicapped population by census tract or other small subarea.
- Small Subgroup Survey - to develop, with the help of local social service organizations, additional documentation on small but important subgroups of the transportation-handicapped population.

The fourth element extends the data collection process beyond the planning and design stages to the monitoring and evaluation stages. This fourth element is:

- Ongoing Service Monitoring - to monitor and evaluate the use of public transportation services by transportation-handicapped people through registration files, on-board counts, and/or service request and inquiry files.

Exhibit 3 illustrates the four-part data collection process described above.

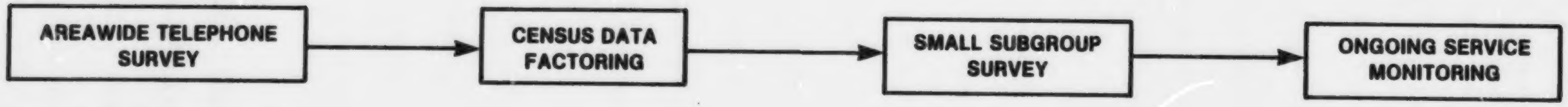
Areawide Telephone Survey

The first step in the recommended data collection process is the areawide telephone survey. The purpose of the survey is to locate transportation-handicapped people and obtain information concerning:

- their disabilities;
- the nature of their travel habits; and
- their transportation problems and needs.

EXHIBIT 3

DATA COLLECTION PROCESS FOR TRANSPORTATION-HANDICAPPED PLANNING


AREAWIDE TELEPHONE SURVEY
CENSUS DATA FACTORING
SMALL SUBGROUP SURVEY
ONGOING SERVICE MONITORING

AREAWIDE TELEPHONE SURVEY

- Screening Questionnaire Identifies Areawide Transportation-Handicapped Sample
- Handicapped Person Questionnaire Provides Socio-Economic and Travel Characteristics of Areawide Transportation-Handicapped Sample

CENSUS DATA FACTORING

- Distribute Areawide Transportation-Handicapped Sample Data to Subarea Level

SMALL SUBGROUP SURVEY

- Augments Areawide Telephone Survey Data with Information on Small Subgroups of Transportation-Handicapped Population Which Might Otherwise be Underrepresented

ONGOING SERVICE MONITORING

- Registration Files, On-Board Counts, and Service Inquiry Files Used to Monitor and Evaluate Public Transportation Use by Transportation-Handicapped People

The areawide telephone survey technique involves contacting by telephone individuals who live in the study area. It requires the use of two questionnaires. The first questionnaire, called the screening questionnaire, enables the interviewer to screen a random sample of households in the study area to identify those with transportation-handicapped residents. The second questionnaire, called the handicapped person questionnaire, is completed only for persons identified in the study sample as transportation-handicapped. This second questionnaire is more detailed than the screening questionnaire since it includes numerous questions regarding the transportation problems, needs, and actual travel habits of the persons interviewed.

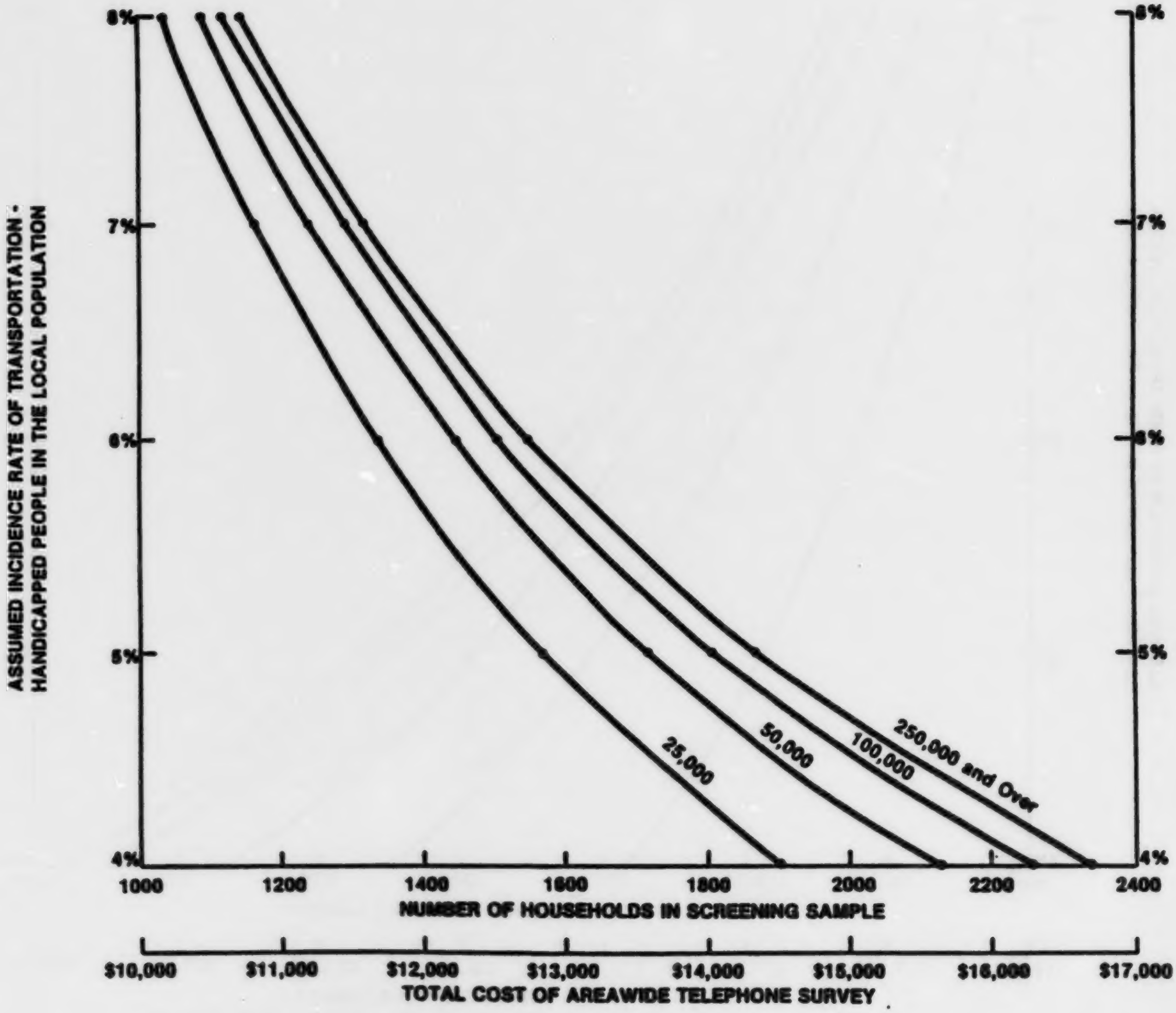
The areawide telephone survey requires a relatively small random sample of residences to be contacted to produce reliable information concerning transportation-handicapped people on an areawide basis (e.g., city, transit district, or Standard Metropolitan Statistical Area). For most local areas, a sample size of two- to three-thousand households should be adequate for estimating the size of the local transportation-handicapped population. A much larger sample would be needed to produce equally reliable information on a disaggregate, subarea basis (e.g., neighborhood, census tract, or travel analysis zone). Exhibits 4 and 5 illustrate the approximate sample size and cost for an areawide telephone survey which estimates the number and trip rate of transportation-handicapped people in urban areas of various sizes. The costs are based on a successful pilot areawide telephone survey conducted in Dayton, Ohio, in 1980.

Census Data Factoring of Areawide Telephone Survey Data

Research has demonstrated that transportation-handicapped people are not uniformly distributed over an entire urban area. Therefore, some method is required to break down the areawide information on transportation-handicapped people to the subarea level of detail.

EXHIBIT 4

SAMPLE SIZES AND COSTS FOR ESTIMATING THE NUMBER OF TRANSPORTATION-HANDICAPPED PEOPLE IN URBAN AREAS OF VARIOUS SIZES[1,2]

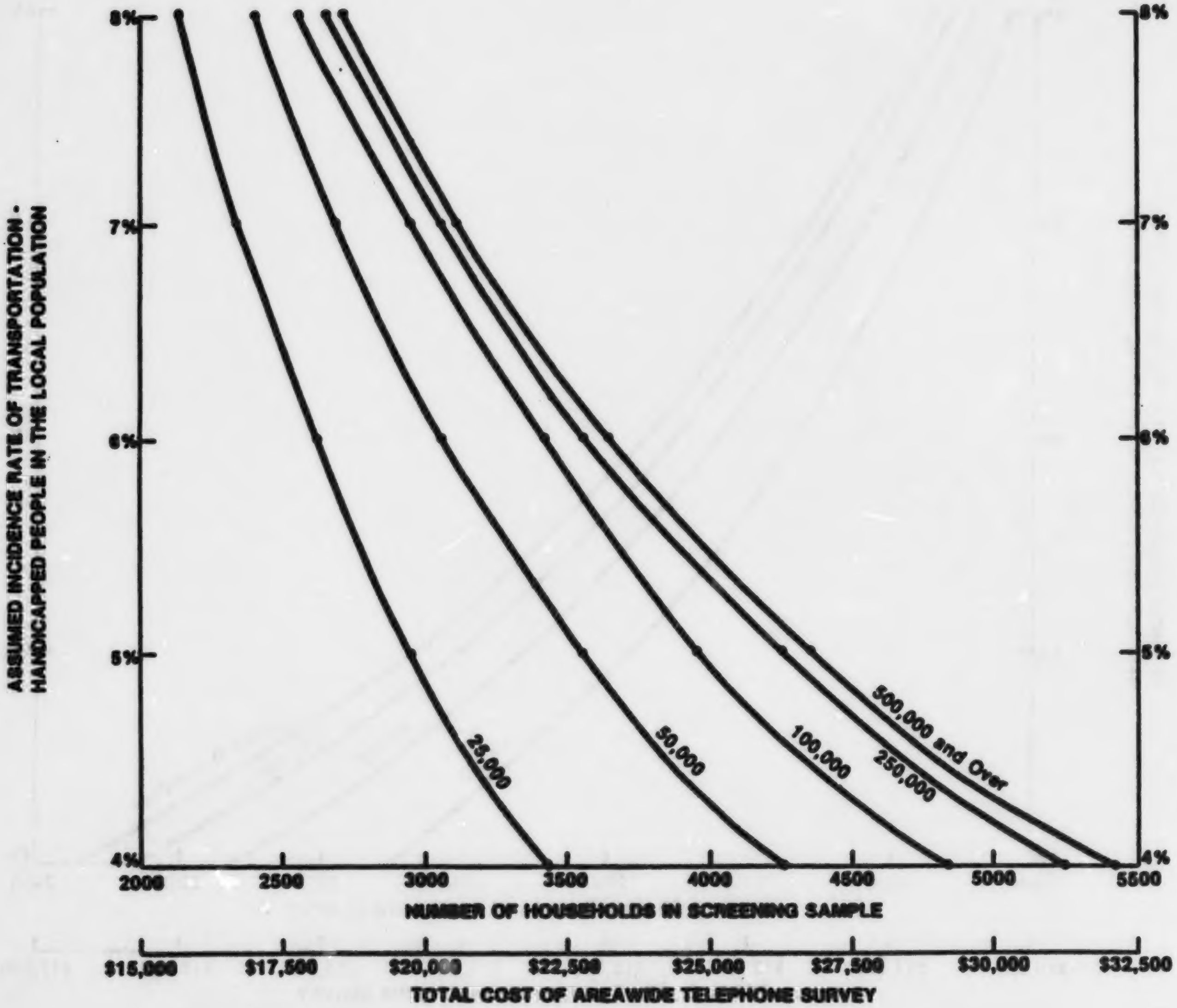


[1] Assuming a 90% Level of Confidence and 10% Relative Error.

[2] Population of Urban Area Indicated on Each Line.

EXHIBIT 5

SAMPLE SIZES AND COSTS FOR ESTIMATING THE TRIP RATE OF TRANSPORTATION-HANDICAPPED PEOPLE IN URBAN AREAS OF VARIOUS SIZES[1,2]



[1] Assuming a 90% Level of Confidence and 10% Relative Error.

[2] Population of Urban Area Indicated on Each Line.

Instead of greatly expanding the size of the sample included in the areawide telephone survey, data from the 1980 Census can be used to disaggregate areawide information to the census tract level. This capability is unique to the 1980 Census, which included a question pertaining to a person's ability to use public transportation due to a physical or mental handicap.

This second element of the process consists of developing the percentage of transportation-handicapped people for each census tract in a specified study area. This is done using the 1980 Census and applying the resulting percentages to areawide data developed from the areawide telephone survey. This is a very cost-effective technique since it provides a single yet reliable method of disaggregating the areawide telephone survey data without increasing the size of the telephone survey sample. For most urban areas, developing and applying census tract percentages of transportation-handicapped people will require only a couple days of staff time, plus the cost of acquiring one or two reels or printed tabulations of census data.

Small Subgroup Survey

The incidence rate of certain subgroups of the transportation-handicapped population, such as wheelchair users, blind people, and mentally disabled people, is usually so small that an areawide telephone survey will not locate enough of them to yield statistically significant information. Therefore, another technique must be used to identify a large enough number of such people to provide meaningful results. This technique, the third step in the recommended data collection process, entails collecting information on such subgroups through the assistance of social service organizations.

This technique is not intended to develop a probability sample of certain transportation-handicappped subgroups, since the sampling technique is neither random nor necessarily representative. It excludes persons within each subgroup who are not clients of the social service agencies or other local organizations. However, the technique can quickly locate a significant number of individuals from small subgroups of the transportation-handicapped population whose views might not otherwise be adequately reflected by the areawide telephone survey results.

The cost of contacting social service agencies and other local organizations to collect information on specific subgroups of the transportation-handicapped population will depend on the number of groups to be contacted and the degree to which such groups will cooperate with the survey team, the extent to which persons within the subgroups belong to any one organization, and the degree to which members are willing and able to supply requested information. Where the survey team is unable to directly contact clients of a particular social service organization, it may be possible to have the organization conduct the interview or distribute self-administered questionnaires to its clients, who can then complete the questionnaire and return it to either the social service organization or the survey office.

Ongoing Service Monitoring

The fourth element of the recommended data collection process consists of techniques for monitoring the use of public transportation services by transportation-handicapped people. These techniques include:

- developing and reviewing registration files of persons using specialized transportation service programs;
- performing periodic counts of transportation-handicapped passengers using these programs; and

- reviewing records of requests for or inquiries regarding specialized transportation services.

Each of these techniques involves developing and using an easily maintained data base to monitor and evaluate the use of public transportation services by transportation-handicapped people. This information can then be used by transportation planners and transit operators to fine-tune or revise their special transportation service programs.

The cost of monitoring the use of public transportation services by transportation-handicapped people depends on many factors, including the technique used, frequency of data collection, extent of data collected, and sample size. Registration files and service request or inquiry records are low-cost monitoring techniques, especially for those organizations already using them in special transportation service programs.

IMPLICATIONS OF THE DATA COLLECTION PROCESS

The data collection process described in this paper has several implications for local transportation planners and transit operators. These include the following:

- The overall process is comprehensive. Both primary and secondary data collection techniques are used to develop local subarea information on the number, location, characteristics, and transportation needs of transportation-handicapped people.
- The process develops statistically reliable estimates of local transportation-handicapped population characteristics, while also providing significant information on small subgroups of the transportation-handicapped population having specialized transportation needs.
- The process is adaptable to local planning needs and resources. Each of the techniques in the process can be tailored to the size of the local area and the resources available to collect data. The techniques represent the most cost-effective procedures for developing comprehensive and reliable information on local transportation-handicapped people.

- The process enhances the usefulness of census data concerning the transportation-handicapped population. The census data are used to distribute independent areawide data to the subarea (census tract) level. This avoids the problems of underrepresentation and data obsolescence which might result from using census data alone to estimate current incidence rates of transportation-handicapped people at the local level.

- The process is relatively simple. Sample sizes are provided in the detailed manual for the areawide telephone survey, based on the local area's population, the confidence level of the estimate, and the relative error of the estimate. Screening and handicapped person interviews are conducted by telephone, thereby avoiding the costs and logistical problems associated with personal interviews and the poor response rates associated with mail-back questionnaires.

DATA COLLECTION MANUAL

Transportation service planners and providers will find much more detailed information as well as instructions on how to apply each of the individual data collection techniques described in this paper in a report entitled: Planning Services for Transportation-Handicapped People, Data Collection Manual. This manual provides step-by-step instructions, cost information, and supporting documentation for each of the recommended data collection techniques. It also contains detailed estimates of the areawide telephone survey sample sizes needed to estimate the incidence and daily travel rates of the local transportation-handicapped population. The appendices to the manual contain illustrative examples of survey forms used in studies which demonstrated each of the techniques used in the overall data collection process.

Copies of the data collection manual can be obtained by contacting one of the following:

(1) Technology Sharing Program (I-30HD)
Office of the Secretary of Transportation
U.S. Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

Title: Planning Services for Transportation-Handicapped People, Data Collection Manual (August 1983)

Document Number: DOT-I-83-40

(2) National Technical Information Service (NTIS)
Springfield, Virginia 22161

Title: Planning Services for Transportation-Handicapped People, Data Collection Manual (August 1983)

Report Number: UMTA-DC-09-9049-83-1

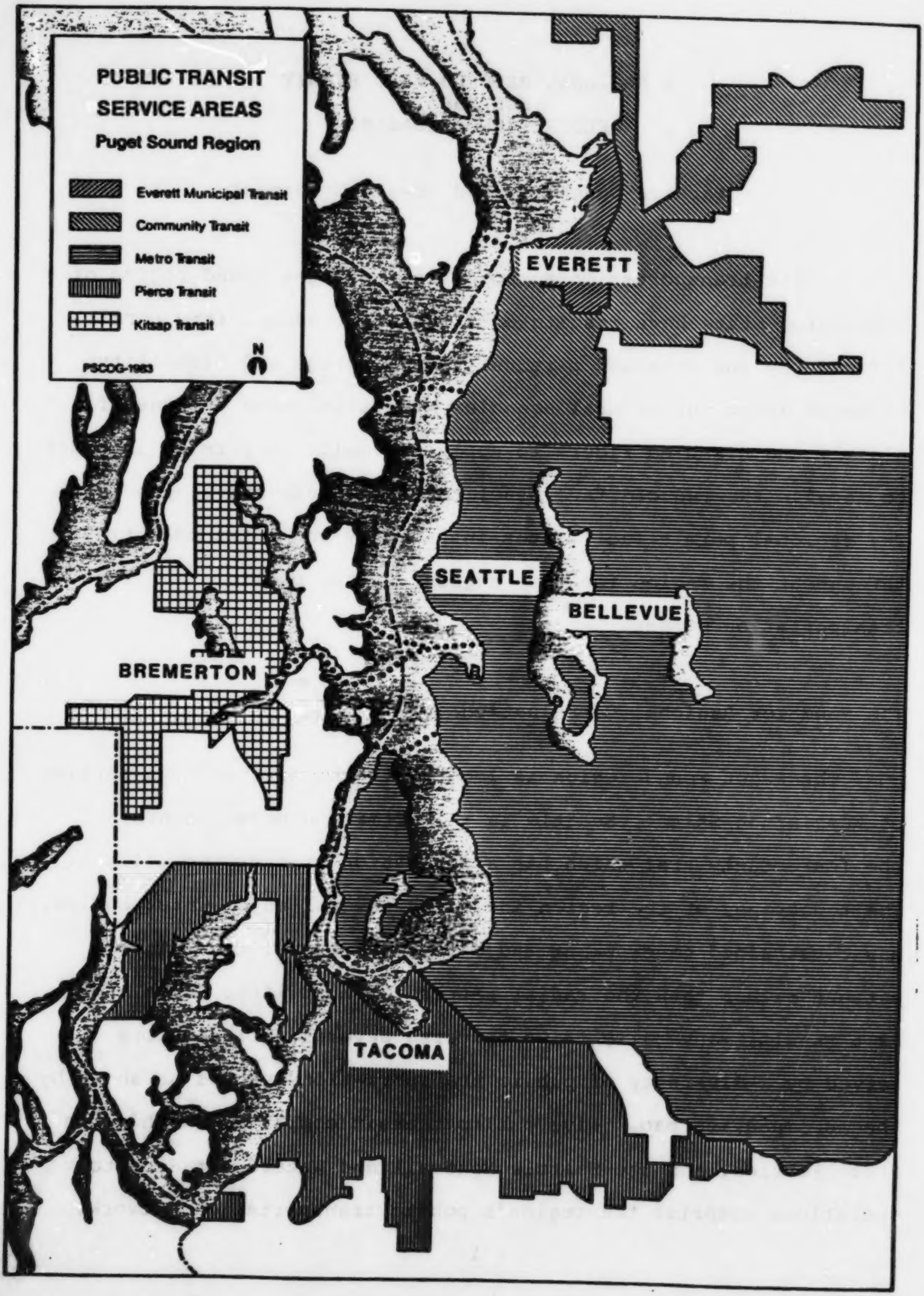
A REGIONAL REDUCED FARE PERMIT
FOR THE
ELDERLY AND DISABLED

by
Barbara Dougherty and Edward McCormack

Public transportation agencies in the Puget Sound region of Washington State have instituted a regional reduced fare permit for elderly and disabled persons. Standard age and disability criteria among the several agencies have eliminated the need for elderly and disabled riders to apply for multiple permits in order to receive the reduced fare benefits of the respective agencies. The regional permit facilitates interagency and intermodal travel throughout the region for this segment of the public transportation market.

The Need for Regional Coordination

The Puget Sound region is located in the northwestern portion of Washington State. Seattle is the primary economic center of the four-county area which has a population of over two million. The topography of the region including several major water bodies, has constrained development and associated travel to a linear pattern rather than the radial pattern of most large urban areas. As a result, many daily trips traverse several jurisdictions served by a diversity of public transportation systems as shown by the accompanying map. Five public transit companies, Washington State Ferries, and the Seattle Monorail and Waterfront Streetcar operations comprise the region's public transportation network.


PUBLIC TRANSIT
SERVICE AREAS
Puget Sound Region
Everett Municipal Transit
Community Transit
Metro Transit
Pierce Transit
Kitsap Transit
PSCOG-1983
N
EVERETT
SEATTLE
BELLEVUE
BREMERTON
TACOMA

All of these systems are federally assisted and are therefore subject to certain mandates regarding elderly and disabled accessibility. These include the provision that during non-peak hours, mass transportation services will be offered to elderly and disabled persons at no more than one half the normal peak hour fare.

Table 1

TRANSIT AGENCY STATISTICS (1983)

Agency	Total Poulation Served	Fleet Size	Route Mileage	Passengers Carried (millions)	Operating Budget (millions)
Community Transit	239,000	70	340	3.6	$ 8.5
Everett Transit	56,200	43	95	1.7	$ 3.2
Kitsap Transit	100,900	79	311	1.0	$ 3.0
Metro Transit	1,315,800	1,145	2,050	62.5	$107.6
Pierce Transit	417,400	184	345	11.5	$ 20.7

The region's public transit systems range from high density urban to low density rural operations. Table 1 shows the variations in service areas, ridership volumes, fleet sizes and operating budgets. Each of these systems operates independently under the governance of its respective board. No formal authority exists to dictate coordinated services or fares. As a result, the fare structures, transfer policies, hours of operation, reduced fare eligibility criteria and procedures, etc., vary widely. Nonetheless, there is a strong commitment toward voluntary interagency and intermodal coordination. Interagency contract services, transfer connections, and coordinated information mechanisms are important characteristics of the regional public transportation network.

Some of this interagency cooperation occurs at the initiative of two or more agencies. But, at the regional level, the key to such cooperative programs as the Regional Reduced Fare Permit is a formal, though voluntary forum of the public transportation agencies established under the Puget Sound Council of Governments (PSCOG). Each of the public transportation agencies in the region is represented on policy and technical committees of the PSCOG through which opportunities for cost-effective, cooperative programs are developed.

The need for a regionally coordinated reduced fare permit was identified in 1980 during the development of plans to meet federal regulations for elderly and disabled accessibility. The PSCOG surveyed the public transportation agencies to determine the range of eligibility criteria, procedures and reduced fare benefits for elderly and disabled persons. The results are displayed in Tables 2 and 3. The agencies collectively agreed that their strong commitment to provide services for elderly and disabled persons within their own service areas would be enhanced by regionwide standards that would facilitate interagency mobility.

Table 2

COMPARATIVE ELIGIBILITY CRITERIA

Agency	Age Threshold	Extensive List of Medical Conditions	Brief List of Medical Conditions	Verbal Statement of Disability	Obvious Impairment
Community Transit	62	*			*
Everett Transit	62	*			*
Kitsap Transit	62			*	*
Metro Transit	65	*			*
Pierce Transit	60		*		*
Ferry System	65	*			*

Table 3

COMPARATIVE BENEFITS

Agency	Reduced Fare	Peak Period Use	Transfer Privilege	Reduced Fare Monthly Passes
Community Transit	$.15 basic $.15/zone	no	no	no
Everett Transit	$.15 blind - free	yes	n/a	no
Kitsap Transit	$.25	no	n/a	$10.00 elderly $ 5.00 disabled
Metro Transit	$.15	yes	yes	$2.00
Pierce Transit	$.25	Only with monthly pass	yes	$10.00
Ferry System	half fare	yes	no	no

Evaluation of Alternatives

Three basic approaches to creating a regional reduced fare policy were evaluated through the interagency forum:

1. **Mutual recognition of the reduced fare permits issued by the respective agencies.** Since each of the transportation agencies had its own locally issued reduced fare permits, an obvious approach to regional cooperation was to institute mutual recognition of the permits among the agencies. However, potential revenue losses for systems with higher age thresholds and/or stricter disability criteria were too great. For example, the value of a reduced fare permit over that of a regular pass for Metro Transit could be as high as $400 over the period of one year. Because federal law prohibits the permitting agency from requiring evidence of residence in the service area, a person could conceivably apply for and obtain a permit from an agency with a lower age threshold or less stringent disability criteria and use it regularly for Metro services at a considerable savings. This approach was thus eliminated from further consideration.

2. **Full integration of the reduced fare policies of the respective agencies.** A regional policy on full integration of fares, eligibility criteria and benefits would require some of the agencies to either increase or decrease their age thresholds and/or disability criteria. Following extensive analysis of the financial implications it was found that potential revenue loss was again the major obstacle. The largest system, Metro, would

suffer a substantial revenue loss if its age and disability criteria were lowered. On the other hand, smaller systems, which could effectively serve markets at lower age thresholds and less stringent disability criteria, would stand to lose existing riders and to suffer negative impacts on their public image by elevating these criteria. Even the concept of phasing the reduced fare policy changes over a period of five years was not acceptable to some systems. This approach was therefore also eliminated from further consideration.

3. **Standard eligibility criteria for a regional reduced fare permit and preservation of existing permits for local use only.** The decision to pursue an approach that would address regional objectives while preserving the local fare-setting autonomy of the respective agencies was the key to the ultimate success of the project. As long as the agencies could continue to issue local permits for use within their own service areas, the negotiation of standard criteria for an interagency permit could progress. Agreement was reached to select the higher age threshold and more stringent disability criteria in use at the time for the issuance of the regional permit. This approach eliminated the potential revenue and ridership losses that prevented agreement on full integration. While some considered that full integration should still be the goal, it was recognized that the greatest public need would be served, at least at the present time, by not excluding existing beneficiaries of reduced fare programs.

Under the combined approach, an elderly or disabled person who meets the criteria established for the regional permit is entitled to pay the amount of the reduced fare in effect in each of the service areas through which he/she travels. Time-of-day restrictions and transfer policies established by the local agencies are not affected by the regional policy. A person who does not meet the regional criteria but who meets the lower age threshold or disability criteria of the agency in his/her own area may still obtain a locally issued permit for use in that area. In either case, the permit is essentially an identification card that is used as proof of eligibility to pay the reduced fare when boarding a vehicle, or to purchase a monthly pass at reduced rates where offered.

Memorandum of Agreement

The formal mechanism for instituting the Regional Reduced Fare Permit is a memorandum of agreement prepared by the PSCOG through the interagency forum. Once finalized, the agreement was formally adopted by the governing boards of the public transit agencies and by Washington State Ferries. The agreement establishes the eligibility and permitting procedures; the design, printing and distribution of the permit; and the preservation of local reduced fare programs.

The disability criteria and permit procedures of the respective transportation agencies were compared and evaluated in light of federal requirements. Agreement was reached on granting eligibility on the basis of one or more of six conditions:

- Proof of 65 years of age or older.
- Proof of current eligibility for Social Security disability benefits or current receipt of Supplemental Security Income Benefits.
- Proof of current disability certification of 40 percent or more by the Veterans Administration.
- Valid medicare card issued by the Social Security Administration.
- Certification by a physician licensed by the State of Washington as meeting one or more of several detailed medical criteria contained in a compendium attached to the agreement.
- Obvious manifestation of one of more of the criteria listed in the compendium as, for example, a multiple amputee.

The agencies also agreed that temporary regional reduced fare permits could be issued. An individual who has an impairment expected to last for a continuous period of not less than three months but where improvement at a future date may reasonably be expected to occur, may apply for a temporary permit which will be valid for up to one year.

Design and Implementation

Permit Design. The design of the Regional Reduced Fare Permit was an important item of negotiation and necessitated the direct involvement of marketing and operations representatives of the respective agencies. Vehicle operators and ticket takers were already required to recognize numerous local permits and passes.

Therefore, the design of the regional permit had to be distinctive and enable quick determination of validity. The physical characteristics of each of the locally issued permits was evaluated and a design was developed. The credit card size permit bears the following features:

- unique title and colored band to facilitate driver recognition
- name of authorized user
- photograph of authorized user
- list of transportation systems on which the permit may be used
- serial number
- expiration date (on temporary permits only)

Printing and Distribution. Several alternatives for producing, printing, and distributing the permit to the public transportation agencies were considered. Obvious possibilities included a pooling or reimbursement of funds from the respective agencies with either the PSCOG or one of the transportation agencies assuming these functional responsibilities. But as demonstrated in many ways throughout this project, as in other regional efforts, the direct involvement of the State Department of Transportation (DOT) was a key factor in the project's success. The State DOT produced, printed and distributed pre-determined quantities of the permits to the participating agencies. The volume printed was based on an estimate of need for three years. Each agency was issued a batch of permits with a unique set of serial numbers to facilitate independent recordkeeping.

Issuance and Operation. Full responsibility for marketing and issuing the Regional Reduced Fare Permit lies with the respective public transportation agencies as part of their own programs. Administrative and operational personnel are trained in the proper issuance and use of the permit. The issuing process requires the agency to provide physician certification forms, to assess proof of eligibility, to complete the permit and to maintain a record of permits issued. The issuing agency types or prints the individual's name on a file card, a portion of which is photographed simultaneously with the individual. The image is reduced in size and the final product is laminated. The individual is charged a $1.00 fee for the permit which is issued immediately. Lost or stolen permits may be replaced through the same process.

In some areas, agencies conduct outreach efforts at senior centers or institutions for the disabled where a number of potential riders may be issued permits. In other cases, selected social service agencies are authorized to issue permits on behalf of the transportation agency. This necessitates mutual trust among the transportation agencies that each will ensure proper fulfillment of its obligations and necessary precautions against fraud.

Issuing agencies must have access to an I.D. card camera to reduce the file card image while photographing the rider. Plastic laminating equipment is also required. The cost for the necessary camera equipment is in the $1800 to $2600 range. For smaller transportation agencies, this expenditure may not be cost-effective. Thus, some agencies in this region are borrowing or sharing equipment with other local government offices. In these cases, the days and hours during which permits may be obtained are designated and publicized.

Potential for Future Expansion

Several opportunities exist for expansion of the Regional Reduced Fare Permit. Even before it was finalized in its present form, three transit agencies in counties adjacent to the four-county region expressed interest in participating in the program and added their names to the memorandum of agreement. Over time, it may be found that a statewide permit may be desirable and feasible. In this case, coordinating roles would shift from the regional level to state organizations including the Washington State Department of Transportation and possibly the Washington State Transit Association. Other future directions might include efforts toward full fare and service integration and incorporation into monthly pass programs for frequent interagency travel.

Summary of Key Factors

The successful negotiation of the Regional Reduced Fare Permit for elderly and disabled persons was dependent upon a number of factors. These have all been covered in detail above but are summarized here because of their importance in considering transferability to other areas.

1. Strong commitment on the part of the public transportation agencies toward increasing mobility for elderly and disabled persons.
2. Voluntary cooperation among the respective transportation agencies through a formal mechanism with sufficient staff support to conduct the necessary surveys, prepare agreements and assist in negotiations.
3. Direct involvement of governing board members, managers, and operations and marketing representatives of the participating agencies.
4. Openness to approaches that meet regional needs without negatively impacting existing ridership and the fare-setting autonomy of the respective parties.
5. Financial support or contributed services from the State Department of Transportation.
6. Flexibility and adaptability to revise and/or expand the program following a demonstration period.

A COMPARISON OF DISABLED TRANSPORTATION SERVICES IN FIVE CITIES

by
Carol T. Everett

August 1984

Submitted for presentation at the
Third International Conference
on Mobility and Transport of Elderly and Handicapped Persons
in October 1984

THE URBAN INSTITUTE
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ABSTRACT

This paper compares exemplary services for providing transportation to the disabled. Two accessible fixed-route bus services and three special services are examined. The services chosen for study were done so on the basis of three criteria. First, they are of interest to other localities because they have had relatively high ridership and good reliability. Second, they represent very different demand and operating environments. Third, they have been monitored quite carefully during their implementation by the Urban Mass Transportation Administration, and as a result have permitted the development of benefit and cost measurements using standardized methods and assumptions. Following a discussion of the exemplary services is a comparative analysis on the basis of: mobility benefits, cost, and level of service criteria (such as eligibility restrictions, geographic coverage, time availability, trip purpose restrictions, etc.).

INTRODUCTION

On September 8, 1983, the U.S. Department of Transportation issued new proposed rules under Section 504 of The Rehabilitation Act of 1973 (48 Federal Register 40784). These proposed rules allow transit agencies to provide paratransit or special services in lieu of accessible fixed-route services. They also set criteria which would govern the nature and level of specialized services offered by transit agencies. These minimum service criteria require that:

- geographic coverage, service times, and fare levels be comparable to fixed-route service;
- no restrictions be imposed on trip purpose; and
- reasonable waiting times be established.

In addition, the rules proposed for the first time a "cost cap" on mandated services, requiring that local jurisdictions spend no more than the designated "cap" either to make their systems accessible, to offer alternative service, or some combination of the two approaches.

These proposed changes signal increased flexibility to local communities considering how best to provide transportation services to their disabled citizens. This paper tries to give planners and decisionmakers in these local communities guidance on how to consider the potential implications of the major alternative service strategies.

Communities have chosen many ways to address the transportation needs of the disabled. These approaches vary along a number of dimensions including:

- the combination of accessible main-line service and paratransit service provided;
- the level and type of transit agency and private provider involvement;

- the amount of social service agency participation as providers and/or as subsidizers;
- the mechanisms used to pass subsidies to the providers;
- the degree of centralized dispatching and control involved; and
- the overall level of service provided (fares, reliability, responsiveness, and "rationing devices").

Among these approaches are services that have proven to be more efficient and cost-effective than others, and that can be termed "exemplary." In this paper, five exemplary services are described and compared: two are accessible main-line services (Seattle, Washington, and Champaign, Illinois), and three are paratransit services (Milwaukee, Wisconsin; Pittsburgh, Pennsylvania; and Lancaster, Pennsylvania). These five exemplary services were chosen for study for three basic reasons:

- They are of interest to other localities because they have had relatively high ridership and good reliability.
- They represent very different demand and operating environments.
- They have been monitored quite carefully during their implementation by the Urban Mass Transportation Administration (UMTA). As a result, it has been posssible to develop consistent measures of benefits and costs using standardized methods and assumptions.

This paper starts off with a description of the distinguishing characteristics of each of the five services and then compares them in terms of costs, benefits, and service levels.

FIVE EXEMPLARY SERVICES

Accessible Fixed-Route Bus Services

The experience with lift-equipped fixed-route bus service has varied enormously around the nation. Two communities which have had documented positive experiences are Seattle, Washington, and Champaign, Illinois.

Seattle's accessible fixed-route bus service has been the most heavily used service of its type in the country. In 1983, Seattle Metro operated 259 lift-equipped buses on 43 routes and had an average of 113 lift boardings per day. A cross-cutting study of accessible fixed-route bus services, completed in 1981 found that Seattle's cost per boarding also was the lowest in the nation--only $16 compared to hundreds of dollars per user for other systems (Casey). The city has had an exceptional service record and high on-time performance compared to other systems. The service is interesting in addition because it is part of a larger "hybrid" approach to addressing the needs of Seattle's disabled, which includes a special service (also administered by the transit authority).

Champaign represents an entirely different demand and operating environment from Seattle. It is a medium-sized urban area, with a young university-oriented population and cold Midwestern winters. Champaign's Mass Transit District (MTD) participated in an UMTA demonstration to test the feasibility of a fully accessible bus system in a cold weather climate. The MTD was not able to achieve full accessibility on all of its 10 routes because of problems encountered with retrofitting its existing vehicle fleet. However, on the three routes which were made fully accessible, the service recorded the highest lift usage as a percentage of total ridership (0.13) of any accessible fixed-route bus service that has been evaluated by UMTA to date (Crain &

Associates, 1983). Champaign's MTD, like Seattle Metro, also administers a complementary special service.

Special Services

Because of the flexibility inherent in paratransit service, there is much more diversity in the way special services for the handicapped (compared to fixed-route accessible services) are organized, administered, and operated. The services in Milwaukee, Wisconsin; Pittsburgh, Pennsylvania; and Lancaster, Pennsylvania, are good demonstrations of this point.

Milwaukee's special service employs a "user-side subsidy" approach to providing door-to-door services to the eligible disabled. The user-side subsidy mechanism differs from the more frequently encountered approach which grants subsidies to providers of transportation services. Under user-side arrangements, subsidies in the form of discounted tickets, charge slips, or others means of purchasing services at reduced rates are issued to eligible users. Each user is then free to patronize the provider of his or her choice, with the provider redeeming used tickets or charge slips for their full value from the subsidizing agency. Providers, thus, receive full subsidies for the trips they serve rather than for maintaining a specified level of service. (Seattle and Champaign's special services both utilize the user-side subsidy approach.)

Milwaukee's service represents one of the largest applications of the user-side approach nationwide. It has been so successful that in 1982 it led the plaintiffs in a 1976 suit urging main-line accessibility to drop their action and to allow the transit agency to stop operating lifts on 250 buses. In return, Milwaukee has committed itself to continued funding for the user-side subsidy service at a level equal to 2.2 percent of the transit system's operating budget. The service also has been credited with improving wheelchair van service--increasing hours of service, permitting more service flexibility--through its stimulation of provider competition (Charles River Associates, 1982).

Milwaukee's special service has received a great deal of attention nationally--most recently in the U.S. Department of Transportation's proposed final Section 504 rules (September, 1983). These rules singled out Milwaukee's program as one that appears to meet many (though not all) of its proposed service criteria "at a cost that does not impose an undue financial hardship."

Pittsburgh's special service, while using the more traditional provider-side approach to subsidy disbursement, has received high visibility nationally because of its centralized approach to service management. In Pittsburgh, the regional transit authority hires an independent organization to design, contract for, market, and administer door-to-door services. This organization, however, neither operates nor subsidizes any of the services. The approach's objective is to minimize per-trip costs by "brokering" the demand and existing supply for transportation services for the disabled in such a way as to maximize the opportunities for ridesharing. The organization, called ACCESS, uses a competitive bidding process to select providers, which in this case includes taxi operators and human service agencies.

ACCESS markets its transportation services to all human service agencies, and assists the 45 participating agencies in scheduling their clients' trips. About half of all ACCESS trips are agency-sponsored, and provided at no cost to the rider. ACCESS also sells two types of scrip. The first, sponsored by the transit authority, provides an 89 percent fare discount on ACCESS to persons who are not associated with a social service agency and cannot use mass transit because of a physical disability. The second, administered by the Pennsylvania Department of Transportation and funded by the state lottery, provides persons 65 years and over a 75 percent ACCESS fare discount.

Lancaster has a much smaller population than either Pittsburgh or Milwaukee, and one that is primarily rural. Its system is interesting because it has combined the key elements of both of the large city programs. It has adopted a centralized approach to service management and at the same time a user-side approach to subsidy disbursement. To administer the system, Lancaster has established a nonprofit organization that selects providers competitively for various sectors of the region and then markets the chosen services to area social service agencies. (This is similar to Pittsburgh's "brokerage approach.") But instead of paying providers on a vehicle service hour or hourly rate basis as in Pittsburgh, providers are paid on a per trip basis as in Milwaukee.

Users receive tickets to ride on the services through social service agencies, which in almost all cases distribute the tickets free of charge when the user is a client. Individuals who are not affiliated with a social servce agency but are unable to use public transportation due to a mental or physical disability can receive trip tickets for 75 cents. The regional transit authority covers the remainder of the trip costs for these users. The Pennsylvania Department of Transportation subsidizes senior trips as it does in Pittsburgh.

A COMPARATIVE ANALYSIS

In this paper, the five exemplary services are compared along three dimensions: service levels, mobility benefits, and cost-effectiveness.

Level of Service Comparison

One of the major questions that arises with any service provided for the disabled is how well it compares in terms of service level to its general public counterpart. The September 1983 proposed 504 rules set out six service criteria that special service systems must meet. These criteria require comparability between the special service and the general public service in the areas of geographic coverage, time availability, fares, trip purpose restrictions, waiting time, and waiting list. Table 1 examines how closely the special services and the fixed-route accessible services match their general public counterparts along these six dimensions.

Probably the most interesting finding from this comparison is that none of the handicapped services, not even the lift-equipped fixed-route services, is completely comparable to its general public "main-line" counterpart. While the lift-equipped bus services in Seattle and Champaign are exactly the same as their general public counterparts in most respects, there are two aspects of the services which are significantly different. First, the geographic coverage of the lift-equipped services is much smaller than that of the general public services. Only about 50 percent of the routes in each community currently are accessible, although both communities plan to make all of their routes accessible. Second, while there are no advance reservation requirements to obtain service, there are longer intervals in the scheduling of the lift-equipped vehicles. One area where the accessible fixed-route services are "superior" to their general public counterparts is fare levels: there are

Table 1

Level of Service Compared to General Public Systems for Five Exemplary Disabled Transportation Services

	geographic coverage	time availability	fares	trip purpose restrictions	waiting time	waiting list
Fully-Accessible Strategies						
Seattle	smaller	same	lower	none	intervals in scheduling service	none
Champaign	smaller	same	lower	none	intervals in scheduling service	none
Special Services Strategies						
Milwaukee	greater	greater for taxi service; less for van service	higher	none	48 hours advance notification for van services; immediate service for taxi users	none
Pittsburgh	greater	approx. same	approx. same	none	24 hours advance notification	none
Lancaster	smaller	approx. same	approx. same	none	24 hours advance notification	none

significant fare discounts for handicapped bus riders in both Champaign and Seattle.

In the case of the exemplary paratransit services, these services also were found to match their main-line counterparts quite closely in terms of most of the service quality indicators. The most glaring exception is the advance reservation requirement for service. The Milwaukee, Pittsburgh, and Lancaster special services all require a minimum of 24 hours advance notification for guaranteed service. In Milwaukee, there is a 48-hour waiting time for van services. But aside from this quality aspect, the special services perform comparatively well--no waiting lists, no trip purpose restrictions--and exceed the main-line services in terms of geographic coverage and time availability in some instances.

Mobility Comparison

Another issue which is of importance in discussing handicapped transportation services is the amount of mobility provided by each service type. In this case, the interesting questions are: what percentage of the eligible handicapped population is served by each type and for what percentage of that group's trips? Are the services creating new trips or are they replacing trips which would have been made by other modes? While the data provided in the UMTA evaluation reports do not allow us to generalize about "before mode" use, they do allow us to make some generalizations about market penetration.

Probably the most interesting finding is that a relatively small number of the transportation handicapped account for much of the travel on the services. Table 2 shows that, except for Milwaukee's special service, nine percent or fewer of all those eligible to use the exemplary disabled services are registered or actually using them. While in Milwaukee 40 percent of the eligible population are registered to use the paratransit service, about four percent of those are making between 30 and 40 trips per month.

Table 2

Cost/Benefit Assessment for Five Exemplary Disabled Transportation Services

	Fully Accessible Services		Special Services		
	Seattle[*]	Champaign	Milwaukee[*]	Pittsburgh[*]	Lancaster
I. Demographic Characteristics					
Eligible users	1,850	378	12,200	30,300[**]	766[**]
Eligible users registered	5%	9%	40%	1%	6%
Total population (1980)	1,269,749	110,000	965,000	1,450,000	157,385
II. Program Characteristics (annual)					
Trips served	24,200	1,835	112,000	78,400	7,100
Program cost	$178,500	$41,505	$865,800	$724,400	$13,900
III. Performance Measures					
Total cost per trip	$7.52	$22.80	$8.91	$10.62	$2.81
Revenue per trip	.15	.18	1.26	1.38	.85
Program cost per trip	7.37	22.62	7.65	9.24	1.96

Note: Costs are expressed in 1980 dollars and all costs and benefits (including trips) are present values obtained by using a 10 percent discount rate over a five-year program period.

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[*] Source: Kirby and Miller (1983).

[**] These are the number of persons eligible for transit agency sponsorship; other individuals are also eligible to use these special services, but through a nontransit funding source.

Another finding is that younger handicapped persons who need less assistance in getting around outside the home make up the overwhelming majority of the users of accessible fixed-route bus services (Crain and Associates, 1981 and 1983). These two findings--small market penetration and high market segmentation--are consistent with other research that has shown that the transportation needs of the handicapped are highly heterogeneous (The Urban Institute, 1984).

And, in fact, in cities such as Seattle and Champaign, which are fully committed to making transit accessible to the handicapped, the transit authorities also have chosen to continue specialized door-to-door services for elderly and handicapped persons for whom accessible transit is still too inconvenient. While fully accessible transit services may satisfy statutory and regulatory requirements, they will not meet all the travel needs of the handicapped population. Hybrid solutions incorporating a mix of accessible main-line service and door-to-door service, such as in Seattle and Champaign, will be the most effective in most urban areas.

Cost-Effectiveness Comparison

Much of the debate on handicapped transportation has centered on the issue of costs and cost-effectiveness. Using the UMTA evaluation reports, The Urban Institute has appraised the five exemplary services over a common five-year program period and expressed all the monetary estimates in 1980 dollars. Table 2 provides cost data that transit agencies considering establishing similar programs could use to calculate, for each service, what would be the average total cost per trip over a five-year program period, the revenue and the net program cost per trip.

These numbers show that under the right conditions, and with good planning and operation, all the service approaches can be relatively cost-effective and reliable. For example, for a larger transit agency to institute an acessible bus service such as Seattle's system today, it would incur an average total cost per trip of approximately $7.50 (in 1980 dollars). If it were interested in instituting paratransit systems similar to Milwaukee's user-side subsidy program or Pittsburgh's brokerage program, the corresponding per-trip costs would be approximately $8.90 and $10.60, respectively.

CONCLUSIONS

From The Urban Institute's work in this field, it appears that a major ingredient for success is the commitment to making the service work, regardless of the service approach. In Seattle, the Metro Council decided to pursue a policy of lift-equipping all of its transit vehicles several years before U.S. Department of Transportation regulations were published requiring full accessibility. The commitment to full accessibility is reflected in Seattle's comprehensive approach to installing lift-equipped service, which included making bus stop improvements, carefully selecting routes for accessible service, undertaking broad marketing and outreach, and providing reliable back-up service in instances of mechanical or other failures. This commitment and comprehensive approach to implementation seems to be missing in those communities that have had disappointing results with their lift-equipped main-line service.

A community's commitment to accessible main-line service does not appear to be one which is based purely on principle, however, and those communities which have developed successful systems seem to have had other factors working in a contributory direction. For example, in Seattle, a significant proportion of its bus fleet was scheduled for replacement when the lift-equipped option was raised. Seattle Metro viewed it as cheaper in the long run to provide accessible main-line service and to encourage mainstreaming than to provide door-to-door service to its entire transportation handicapped population.

Another factor which appears to contribute to a community's commitment to accessible main-line service is the existence of major rehabilitation facilities or services geared to helping the disabled person become more independent. For example, Champaign's unusually large and active handicapped population is largely explained by the fact that the local state university has a nationally known rehabilitation/education program. Its presence has led to the remodelling of a large number of public buildings to accommodate wheelchairs, to an aggressive curb-cutting campaign, and to the provision of an accessible fixed-route shuttle bus service on campus.

A factor that may not be as important as originally thought is weather. Evaluation data from Champaign shows that month-to-month demand for lift-equipped service varies very little and lift denials are only 1.7 percent of total attempted lift boardings (Crain & Associates, 1983).

A characteristic that is similar for all the service types is relatively low density, i.e., for any given geographic area and time period, only a small number of trips are made. It is this characteristic which makes sharing of disabled rides difficult to accomplish, and results in overall costs per passenger trip and per passenger trip mile that are quite high by comparison with home-to-work and general purpose programs. The most cost-effective service approach for a community will depend upon its specific objectives as well as its local demand and supply conditions. In some cases the "best" approach will be an accessible main-line approach (Johnston, Pennsylvania is an example), in other cases a paratransit approach (such as in Milwaukee and

Lancaster), in other cases a combination or hybrid approach (such as in Seattle and Champaign), and in still other cases an "open options" approach where paratransit is used now but full accessibility is not foreclosed as a future service approach. Pittsburgh represents this last category. While it currently relies upon a door-to-door service for those individuals who cannot ride main-line transit, it is "building in" accessibility incrementally as it makes major new capital investments in transportation.

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Rescinding Full Accessibility: The Pennsylvania Experience

Submitted to the Third International Conference
on Mobility and Transport of Elderly and Handicapped Persons

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FEDERAL REGULATORY CHANGE

When Ronald Reagan took office in January 1981, three elements of his economic agenda were traditional: budget, tax and monetary policy. But the president and his advisers decided to add a fourth--one that was not traditional--regulatory relief. Regulatory relief's mission was to remove the intrusive presence of the federal government into business, the lives of private individuals, and the day-to-day activities of state and local governments.

An important early initiative taken under the aegis of the regulatory relief campaign was the much-publicized rescission of Carter administration regulations which required that public transit systems be made "fully accessible" to the disabled. The proposed rescission followed conveniently on the heels of a federal court decision, APTA v. Lewis[1], which had thrown the validity of the Carter rules into doubt. In its decision, the U.S. Court of Appeals for the District of Columbia held that while the legislative provision on which the rules had been based (Section 504 of the Rehabilitation Act of 1973[2]) banned discrimination, it could not support the expensive, affirmative steps which had been mandated. Given Section 504's legal inadequacy, the court remanded the rules to DOT, calling on the agency to provide other legislative support for the regulations.[1] In the wake of the ruling the administration simply withdrew the regulations, proclaiming that resulting changes would save transit operators over $2.2 billion in one time costs over a 30-year period.

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[1] APTA vs. Lewis, 556 F. 2d 1271 (D.C. Cir., 1981).

[2] Section 504 of the 1973 Rehabilitation Act reads:

> "No otherwise qualified handicapped individual shall, solely by reason of his handicap be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance." 29 USC 794.

Under the terms of the full accessibility rules, local transit agencies would have had to:

- equip every bus purchased after July 2, 1979 with a wheelchair lift;
- retrofit or equip subways and other rail systems with elevators or other gap-closing mechanisms which would allow the handicapped to board trains;
- make all "key" subway and commuter rail systems accessible within three years as well as at least one car per train; and
- ensure that all new subway cars purchased after July, 1979, and all new commuter rail cars purchased after January, 1983 be lift-equipped.

In place of the withdrawn rules, the Department of Transportation revived an earlier set of regulatory standards--standards which substantially relieved the regulatory burden formerly felt by transit agencies. The new rules required only that transit agencies:

> "certify that special efforts are being made in their service areas to provide transportation that handicapped persons, including wheelchair users and semi-ambulatory persons can use..."

Even DOT offi cals acknowledged that the new rules were, for all intents and purposes, simply advisory as the "special efforts" asked of local service providers was given no specific content.[1]

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[1] Regulatory policies governing transportation for the disabled derive in large part from three separate pieces of legislation: Section 16(a) of The Urban Mass Transportation Act of 1964, Section 165(b) of the Federal Aid Highway Act of 1973 and Section 504 of the 1973 Rehabilitation Act. Over the past several years, it is the latter which has dominated the concerns of federal policy-makers.

But if the last decade has taught us anything about federal efforts to regulate transportation services for the disabled, it is that the legal and political lives of proposed regulatory schemes are rarely long. The permissive character of the administration's 1981 regulations ran into political problems, spurring the Congress to call for more precise and exacting rules. As a result, by September 1983, new proposed regulations had again been issued by the U.S. DOT. This time federal proposals attempted to steer a middle course between the highly prescriptive 1979 "full accessibility" rules and the "anything goes" 1981 regulations.[2]

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[1] The regulation suggested that such service be "reasonable in comparison to that offered the general public" and consistent with one or more of three examples of satisfactory special efforts. The three examples are: (1) the expenditure of an average annual dollar amount equal to 3.5% of the total operating subsidies provided the system under UMTA's 5 program; (2) the lift-equipping of one half of a system's bus fleet--or the provision of a comparable, substitute service; and (3) a system of any design which would provide every wheelchair user or disabled person 10 round trips per week at fares comparable to bus trips.

[2] Among the changes included in the regulations proposed on September 8, 1983 were requirements:

- that all handicapped and elderly citizens unable to use public transportation be eligible for specialized services. (Thus, special services cannot be restricted to, for example, the ambulatory impaired);
- that system's not offering fully accessible service to the disabled spend a minimum of either 7.1% of their average annual amount of federal assistance, or 3.0% of their average operating budget on specialized services. Only expenditures which have been made by the transit agency itself--not those made independently by social service agencies--can be taken into consideration. (This provision is often referred to as a "cost cap".); and
- that transit agencies providing specialized services make those services conform to the following six criteria to the maximum extent practicable:
  1. that specialized transportation serve the same geographic area as transportation provided the general public;

As the above review of developments which have taken place over the course of only the last five years indicate, change is the salient characteristic of federal policy regarding public transportation and the disabled. We contend that these frequent and major changes have created confusion at the state and federal levels of government as to the direction of federal policy, and have resulted over time in a reduction in federal influence over the shape of local programs.

In the fall of 1982, The Urban Institute, with support from the Pew Memorial Trust and Atlantic Richfield Foundation, began a 24-month study of the impact of federal regulatory change on the provision of public transportation to the disabled. The study focused on the experience of three Pennsylvania cities: Philadelphia, Harrisburg, and Erie. Our site selection was premised upon the assumption that the problems facing Pennsylvania (whose population is among the oldest in the nation) and its urban areas are representative to some extent of those confronting the country's industrialized, frost-belt states. Accordingly, we believe that our principal findings may not only be directly relevant to other Pennsylvania cities, but they may also be of regional, if not national, significance.

Before moving to a brief description of the impact of these regulatory

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2. that service hours and days are the same as those provided the general public;
3. that fares are comparable to general fares;
4. that no purpose restrictions be imposed on travel by the disabled;
5. that reasonable waiting times are observed;
6. that no waiting lists are maintained, i.e., the service system should have sufficient capacity to service all eligible users.

See, generally, 48 F.R. 40684, September 8, 1983.

changes on our case study sites, I would like to offer some speculations on why policy in this area has been in such flux and on the political, as well as the judicial rejection of the "full accessibility" regulations.

Full accessibility suffered a number of political liabilities. First, and by far most importantly, full accessibility appeared and, in fact, was, expensive. In 1979 the Congressional Budget Office calculated that the cost of the rules could be as high as $6.8 billion over 30 years (in 1979 dollars). CBO predicted that even if federal subsidies were accounted for, costs of that magnitude would compel local governments to reduce existing services, increase local taxes, or shift other program resources into public transportation.[1]

However, one-time capital cost calculations typically ignored at least two important mitigating factors. First, approximately 75% of public transit systems' capital costs (including the acquisition of new buses, rail cars, and stations) have been assumed by the federal government, with the remaining 25% financed by a combination of state and local entities.[2] As a result, the incremental cost to local jurisdiction of purchasing accessible equipment was often more modest than was claimed by local officials. Secondly, alterations in fixed facilities and rolling stock could often be accomplished more economically than was claimed. For example, the total capital expenditures required to retrofit existing rail stations could be reduced substantially by scheduling retrofitting along with the major repairs that many older, urban rail stations would be compelled to undergo over the next 30 years.

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[1] See, for example, U.S. Congressional Budget Office, Public Transportation for Handicapped Persons: Alternative Federal Approaches, Government Printing Office, 1979.

[2] Federal contributions to public transportation companies' capital programs should be contrasted with federal support for transit agencies' operating expenditures. Currently, only a maximum of 50 cents out of every operating dollar is provided by the federal government. Moreover, the Reagan administration has repeatedly sought the total elimination of federal operating subsidies. (In almost all jurisdictions paratransit service for the elderly and handicapped are paid for out of operating rather than capital dollars.)

In addition to the controversy which arose over full accessibility's costs, the rules raised questions of political authority as the 1979 regulations were highly prescriptive--particularly when contrasted to the far more flexible "special efforts" requirements which had preceded and followed them. Thus, the scheme they established removed much of the discretion formerly available to transit operators and was viewed as an arrogation of local government authority. Indeed, a report published in February 1984 by the U.S. Advisory Commission on Intergovernmental Relations (ACIR) stated that Section 504 of the 1973 Rehabilitation Act was ranked by state and local officials as the most burdensome federal mandate with which they had to cope.[1]

Along similar lines, resistance to the regulations also owed to the fact that the requirements to develop and administer transportation programs for the disabled fell to a set of organizations--public transit agencies--which had not previously been involved in serving special populations. Moreover, the newly assigned responsibilities had to be carried out, for the most part, within existing funding--funding which, as I have indicated, was being steadily reduced. As a result, many operators saw their obligation to comply with the regulations as being in direct conflict with their traditional obligation to provide transportation to the general public.

Another political liability of the full accessibility approach derived from the fact that its emphasis on fixed-route accessibility did not meet the diverse needs of the entire disabled community. Indeed, the apparent focus of

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[1] See, Regulatory Federalism: Policy, Process, Impact and Reform, The Advisory Commission on Intergovernmental Relations, Washington, D.C., February, 1984, p. 184.

the rules was to provide transportation for that segment of the population which was wheelchair bound or had other orthopedic disabilities. Thus, the transit solutions developed (the placement of ramps in rail stations and lifts in buses, e.g.) did not promise to meet the needs of individuals with perceptual handicaps, the mentally retarded or even the very severely ambulatorily impaired.

Finally, the vulnerability of regulations derived from Section 504 of the Rehabilitation Act to judicial and political attack owed to some extent to the language of Section 504 itself--language that was drawn directly from Title VI of the Civil Rights Act of 1964. Hence, Section 504 states only that:

> "no otherwise qualified handicapped individual in the United States shall, solely by as reason of his handicap, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."[1]

As Peter Schuck, a Professor at Yale Law School has pointed out, Title VI and, by extension, Section 504, embody what can be termed the "nondiscrimination model" of civil rights law. As Schuck notes:

> "The nondiscrimination model is wholly prohibitory. It neither instructs the person to whom the command is directed what to do or how to do it, nor in any way defines his task or identifies the factors or objectives that should inform his exercise of discretion."[2]

Given the nonspecific nature of this legislative language and the provision's comparatively sparse legislative history, it is not surprising that development of a final, legally and politically supportable set of regulations has proven elusive. In this regard, political and legal vulnerability of regulations governing transportation for the disabled promulgated under Section 504 offer an interesting contrast to federal regulations setting minimum standards for educating disabled children. The latter derive from far more specific and prescriptive legislative language (P.L. 94-142, The Education of All Handicapped Children Act) and have proved to be more durable in the courts, the Congress, and even in federal administrative agencies.

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[1] P.L. 93-112, 93d Cong. September 26, 1973.

[2] Peter Schuck, "The Graying of Civil Rights Law," The Public Interest, Summer 1980, p. 69.

URBAN TRANSIT SYSTEMS' RESPONSE TO REGULATORY CHANGE

We are rarely presented with a better opportunity to study the way federal regulations and regulatory change influence local policy decisions than that offered by the recent history of DOT's Section 504 regulations. First, sweeping policy changes and summary reversals occur within a short period of time. Second, we have inherited a rich, detailed record of what local responses and their projected costs would have been had the 1979 full accessibility regulations not been withdrawn. That record is contained in a set of federally mandated transition plans which set out the nature, timing, and costs of local government responses to DOT's "mainstreaming" rules. In the following section I briefly describe three Pennsylvania cities' proposed responses to DOT's full accessibility rule, as well as the service changes adopted after the regulations' withdrawal.

The three jurisdictions surveyed in this preliminary report--Philadelphia, Harrisburg, and Erie--differ in a number of significant ways. First, of course, they vary dramatically in terms of population and spatial size. Second, they differ in the nature of the existing transit systems they support: from Philadelphia's mix of 1500 buses, its light, commuter and rapid rail systems, its trackless trolleys, and paratransit service, to Erie's comparatively small bus fleet and paratransit operation. They also differ in the public/private nature and origin of principal service providers. In larger communities--Philadelphia, for example--the public sector has been primarily responsible for delivering transit services to the disabled. Their efforts typically originated in response to federal mandates and have shifted through time to fit the shape of those commands. In small and midsize communities, transit services for the disabled have been developed and carried out in large part by private nonprofit organizations. Not created to satisfy federal dictates, local transportation services were, rather, designed to meet perceived local needs. Perhaps as a result, they have altered less as federal rules have changes, and have provided a more uniform, somewhat lower level of service through time.

Philadelphia

Philadelphia is served by the Southeastern Pennsylvania Transportation Authority (SEPTA) which runs the region's complex, rail-oriented transit system. Given the system's multi-modal character and its aging fixed-rail component, full accessibility was likely to prove complicated and extraordinarily expensive due to the high costs of elevator installations, platform gap-filling mechanisms, and road-bed adjustments.

Philadelphia's first major, concerted effort to accommodate the disabled began in the mid-1970s. At that time SEPTA joined with several other large urban transit authorities to order a federally designed bus--the Transbus. Federal standards, among other things, were designed to meet elderly and handicapped accessibility requirements primarily through the use of wheelchair lifts. However, those standards were found by all major bus manufacturers to be costly and unworkable. As a result, no bids were received for the bus' construction and after a long and difficult political and legal history, the project was abandoned. SEPTA officials claim that their own efforts to provide transit services for the disabled were set back by two years during the time they waited to take delivery on the new bus and that their future efforts to accommodate the disabled lost a measure of political credibility.

But the Transbus debacle was not all that was happening during this period before full accessibility. Federal officials, acting on a somewhat ad hoc basis and relying heavily on architectural standards advanced by the federal Architectural Barriers Compliance Board, compelled SEPTA to make structural changes to a number of fixed facilities, eventually leading to the installation of ramps at twenty commuter rail stations. But while some stations may now be accessible, none of the rail cars which currently serve those stations are, as retrofitting SEPTA's new rail fleet was deemed too expensive. Moreover despite the fact that 40 "accessible" cars were recently purchased, their design does not permit motorized wheelchairs to turn from the rail car's entryway into its body.

In response to the promulgation of federal full accessibility requirements, SEPTA proposed a plan which included four major capital elements: the exclusive purchase of lift-equipped buses (so that half the peak hour fleet would be accessible by 1989); conversion of key rapid, light, and commuter rail stations to wheelchair accessibility; a retrofitting of rapid and commuter and light rail cars so that at least one car per train was accessible; and the future purchase of accessible light rail and trackless trolley cars.

An array of future capital and operating cost projections was subsequently issued for the proposed accessibility plan. Estimates by the Delaware Valley Regional Planning Commission presented in the Commission's transition plan set one-time full accessibility capital costs at approximately $57.9 million (in 1980 dollars) over 30 years with annual operating costs running $4.3 million. Other cost estimates found in an UMTA-funded Rail Retrofit

Evaluation Study projected the 50-year cost of converting the system's rail stations to full accessibility at $519 million. The inherent difficulty of making such long-term capital forecasts tends to limit their usefulness, however, the numbers cited above suggest that full accessibility was going to impose significant costs.

The regional transit authority responded to the federal government's withdrawal of full accessibility regulations by taking three steps. First, the SEPTA board voted to delete lifts from all future bus orders. At the time of the decision, 450 lift-equipped buses were either in service or on order, constituting 30 percent of the system's total fleet of 1500. Second, conversions of rail stations to full accessibility slowed as future conversions were limited to new stations or those where modernization expenses exceeded 50 percent of the replacement cost of the facility.[1] Third, a publicly administered, citywide paratransit agency was created, beginning operation in 1983.

The paratransit system employs a "brokerage" model developed for the city of Pittsburgh. Following Pittsburgh's example, SEPTA has contracted with a private, nonprofit firm, WHEELS, to arrange door-to-door paratransit service for the region's disabled and handicapped. To that end, WHEELS has contracted with a group of private, nonprofit and for-profit entities which will actually provide the transportation. WHEELS operates a central clearinghouse, scheduling rides and parcelling out requests for travel among subcontractors (principally on a regional basis). The paratransit system's first year costs were approximately $2.5 million. Total costs for the paratransit program in FY 1984 were $2.96 million; for FY 1985 they are expected to be $3.77 million.

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[1] The installation of other accessibility features could, however, be more widely observed. They included continuous handrails, tactile warning strips, high contrast warning stripes, accessibility grading, telephone placement, and accessible pass gates.

At least on paper, SEPTA's paratransit system imposes relatively few constraints on travel. The system's hours of operation are comparatively long--from 6 a.m. to 10 p.m. on weekdays, 8 a.m. to 12 midnight on Saturdays, and 9 a.m. to 5 p.m. on Sundays and holidays. No purpose restrictions are imposed on elderly and disabled travellers. The system's range of service is roughly comparable to SEPTA's mainline services and system fares remain comparatively low--approximately $1.00 per ride. Finally, social service agencies retain authority to certify those eligible for paratransit.

To date, though, the paratransit system has been swamped by demand. And, as rides have been provided on a first-come, first-served basis, late requests for service are denied--regardless of travel purpose. At the time of our survey, SEPTA managers estimated that as many eligible riders are turned away each day as are provided service. Moreover, this estimate does not account for the many callers who abandon attempts to arrange for a ride because the centralized phone lines are perennially busy.

The congestion owes to a number of factors. One of the most important is the fact that formal relationships developed slowly between SEPTA and the city's many social service agencies--most of which were being hit by the effects of reductions in state and federal funds at the time the paratransit service was getting underway. As a result, many of those agencies saw the paratransit system as a substitute for, rather than a supplement to, the transportation services they were already providing. Thus, they simply transferred their transportation responsibilities to SEPTA and applied the freed-up resources to other program uses. In addition, WHEELS and SEPTA have been slow to move to a computerized phone and scheduling system. SEPTA paratransit currently provides approximately 500 trips per day at a cost of approximately $16 per trip.

Since the introduction of paratransit service, the city has placed less emphasis on providing lift-equipped, main-line service. Use of this service has fallen from 177 trips per month in September 1982 to 45 in June 1983.

As this brief history suggests, SEPTA's efforts to provide meaningful transportation to the disabled have proceeded by fits and starts over the course of the past decade, with halting progress at least partially attributable to shifting federal requirements. Ironically, the recently adopted paratransit system was initially contemplated by the authority during the 1976-1977 period when it was also deliberating over whether to adopt the Transbus. Expecting that the federal government would adopt a full accessibility standard, needing to replace part of the bus fleet, and suspecting that paratransit would not fit into the traditional "family" of transit agency services, SEPTA decided in favor of the Transbus. Seven years and three sets of federal regulation later, the authority has come full circle--at a substantial cost in terms of operating experience, efficiency and political good will.

Harrisburg

Local government officials in the Harrisburg area made no secret about their feelings toward federal full accessibility requirements, prefacing their 1980 Transition Plan with a "Statement of Objection." The statement, which deserves to be quoted at length reads in part:

> "...Emphatic objection is hereby stipulated to both the method and costs mandated by the Federal Government requirements to which this Transition Plan is addressed.
>
> We object to the tactic of mandating a new expensive program under the threat of withdrawing funding support for existing programs.
>
> We object to the tactic of mandating a program which will generate larger costs without providing sufficient federal funding to support those costs and which will require large cost contributions by our local governments.

> As local governments we find our required activities, mandated from higher levels, being continously broadened and deepened, while the funding assistance provided is not being increased adequately for newly-required programs, and may even be reduced. Faced with funding problems which are likely insurmountable, with a tax base considerably smaller and taxing power severely limited (compared to that available to higher governments), and with essentially no power to employ deficit financing, the inevitable results will be governmental collapse at worse, or wholesale non-compliance with mandated programs at best."[1]

Despite the resentment the rules generated, Harrisburg's Capital Area Transit Authority (CAT) committed itself to retrofitting and placing 17 lift-equipped buses on eight designated routes by July 1, 1982, and to making 61 of the authority's 91 buses accessible by July, 1989. In addition, approximately $45,000 was to be provided in annual support to a private nonprofit paratransit service for the elderly and handicapped until fixed-route transportation became available.

Given the animosity to federal requirements expressed in the area's transition plan, it is not surprising that significant service changes were made with the enactment of the permissive special efforts rules. Among them were a summary cancellation of the lift-equipping of CAT buses and the substitution of a modest CAT-administered paratransit program to replace the city's more ambitious but financially troubled predecessor.

Among the new restrictions to the operation of CAT's two-van paratransit effort, which coincided with the promulgation of the "special efforts" rules were:

- a reduction in the operating hours of the service to the eight-hour period extending from 8:30 a.m. to 4:30 p.m. Members of the local disabled community point out that the work day begins for most people in this state capital at or before 8:00 a.m.

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[1] See, "Amendments to the Transition Plan for the Harrisburg Area: Accessibility for the Handicapped In Public Transportation," Tri-County Regional Planning Commission, Capital Area Transit, June ,1981.

- A shift in the policy regarding eligibility certification for disabled users. Formerly social service agency personnel could certify paratransit eligibility; only doctors are now permitted to do so.
- A curtailing of disabled involvement in transit planning, with no meetings involving the elderly and handicapped having been held in the past three years.
- The imposition of strict trip priorities as travel is permitted only for work, medical/therapy, and shopping. No social travel is permitted.

Not surprisingly, Harrisburg's paratransit service has been criticized by local disabled citizens for operating fewer hours, for having a substantially more restricted spatial range than mainline service, and for its imposition of travel restrictions.

In part as a result of these rationing devices, use of the system is quite limited, with only six or seven regular riders. Approximately ten trips are provide each day at an approximate cost of $23 per trip.

Erie

Finally, let me briefly summarize our observations in Erie, Pennsylvania. Erie's opposition to federal full-accessibility regulations drew national attention when the regional transit authority claimed that it had surveyed its entire wheelchair-bound population and that they had been unanimous in their opposition to making fixed-route transportation accessible in lieu of continuing the existing paratransit service. Thus, it is not surprising that the Erie Metropolitan Transit Authority (EMTA) welcomed the opportunity to sustain limited accessible main line service to the disabled when federal full accessibility regulations were lifted.

The regional transit authority contracts with a single cab company to provide paratransit service. Users make their own arrangements for service, paying with tickets which cost 30 cents apiece. The taxi operator is paid a maximum of $4400 each month, and once rides are provided equalling that sum in metered fares the taxi operator suspends service until the next month. All disabled persons are eligible to use the service.

Fare for the service is one-half the regular transit fare, the service area is the same as for the fixed-route transit service, and the service is available twenty-four hours a day. However, as in Philadelphia, demand far outstrips the funded-level of service. This has led to severe trip restrictions (work and medical) and to routine service stoppages which usually occur well before the end of each month.

SUMMARY

Our research to date indicates that, in terms of federal policy:

- Despite years of federal activity in the area of providing transportation to the disabled, no enforceable minimum service standards are currently in place.
- To date no enforcement action has been taken by the Department of Transportation under any of the several sets of regulatory standards promulgated under Section 504.
- Despite the absence of meaningful minimum federal standards and enforcement, federal policies remain preeminent in many states such as Pennsylvania which have yet to exert their own independent regulatory authority in a way which would insure minimum program quality levels across jurisdictions.
- Despite the sharp reduction in minimum federal program standards (as embodied in the administration's 1981 interim standards and its 1983 proposed final standards), few if any consequential legal challenges have been initiated by the disabled.

At the local level we found in each of our case study sites that the transit authority expressed a strong antipathy to adopting the accessible main-line approach to service provision required by the 1979 regulations. Since the relaxation in federal regulations, we have observed a significantly increased emphasis on specialized transportation approaches and, correlatively, a de-emphasis on lift-equipped fixed-route transit service.

In each instance we have also seen paratransit services which fall short of comparability with fixed-route bus service. Indeed, severe supply constraints reflected in trip priorities or other less structured forms of rationing meant that these systems offered inferior mobility to the paratransit options in the set or "exemplary" case study sites also examined over the course of the project.[1] This finding, in turn, suggests that one result of recent federal policy changes may be the development of transportation programs which provide service of widely varying quality and utility to disabled users, across states and across the nation.

POLICY IMPLICATIONS

In the wake of the rescission of the Carter administration's full-accessibility regulations, the clear trend observed in each of the case study sites has been to demand-responsive service systems. Accordingly, the central focus of these comments on prospective federal policies will go to the operation of these and other alternatives to fixed-route conversions.

Minimum Mandatory Service Criteria. We believe that local special service transportation programs (encompassing all demand-responsive alternatives to making fixed-route systems accessible) should be measured by service criteria designed to promote "equivalent" levels of mobility to that enjoyed by the general travelling public.[2] Service criteria should embrace the standards set out in federal regulations promulgated in September, 1983. They should insure service over the same area, during the same hours, at comparable fares, with no priorities assigned to trip purpose, imposing reasonable waiting times, and prohibiting the use of waiting lists. In addition, we subscribe to the 1983 regulation's broad requirement that all transportation handicapped persons unable to use conventional fixed-route transit systems be eligible to use such services, not just those who are wheelchair bound, ambulatorily impaired, or blind.

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[1] Those sites included Seattle, Washington; Champaign, Illinois; Milwaukee, Wisconsin; and Lancaster, Pennsylvania. See, generally, C.T. Everett, "Strategies for Delivering Disabled Transportation Services: Several Exemplary Approaches" prepared for the Third International Conference on Mobility and Transport of Elderly and Handicapped Persons, The Urban Institute, September 4, 1984.

[2] Door-to-door service is not equivalent to travel on fixed-route systems in that in some respects it represents superior service. Thus our conclusion is cast in terms of equivalent mobility, not service.

Local efforts should be compelled to meet these program criteria rather than other standards (such as expenditure targets)[1] for a number of reasons:

- the use of this type of performance standard creates an incentive for cost-effective, resource-conserving compliance strategies (such as relying on travel training for the mentally disabled);
- this type of standard does not implicitly reward jurisdictions which have done little to date to meet the transportation needs of the disabled;
- the standard can be phased in over time to ensure that cost burdens can be absorbed by jurisdictions;
- it offers maximum flexibility in designing local programs; and
- it is consistent with the controlling federal court decision, which held that only "modest affirmative" steps can be compelled by the federal government under the dictates of Section 504.

In addition, we believe that this concentration on outputs rather than inputs is far more likely to result in a uniform minimum national standard of service and thus be consistent with clear, recent statements of Congressional intent.[1]

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[1] Regulations proposed in September 1983 by DOT set a "cost cap" or expenditure limit for specialized transportation systems which jurisdictions would not be legally obliged to exceed--regardless of the effectiveness or comparability of the program offered. Such an approach might provide an incentive for "creative accounting" or constitute a permanent waiver for some systems.

Alternative Funding Mechanisms. Second, we believe that the Congress should contemplate an alternative funding approach to subsidizing transportation for the disabled. As we have suggested, funding to support the operation of special transportation services presently derives in large part from federal grants for operating assistance provided to local transit agencies under Section 9 of the UMTA Act. While the administration has yet to achieve its objective, it has announced that it intends to phase out this operating assistance altogether. Thus, current and proposed budget policies have only acted to reinforce the conflict that many transit agency officials feel between their responsibility to serve the general public and their responsibility to serve the disabled.

Accordingly, we suggest that a direct, dedicated funding mechanism be created--one which would resemble that proposed by the Erie County Council on Transportation for the Elderly and Handicapped.[2] The approach contemplates a direct federal contribution to the delivery of transportation services to the disabled. The Erie plan would have local agencies expend 3 percent of the operating budget on special services and the federal government provide a 150 percent match. We would suggest, however, a somewhat lower, perhaps equivalent, level of mandatory federal support.

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[1] See, for example, letter of December 8, 1983, to Elizabeth H. Dole, Secretary of the U.S. Department of Transportation, from Senators Alan Cranston and Donald Riegle with regard to intent of Section 317(c) of the Surface Transportation Assistance Act of 1973.

[2] Comments by the Erie County Council on Transportation for the Elderly and Handicapped on proposed Department of Transportation 504 Regulations, November 18, 1983. See also comments filed by the City of New York for similar recommendations.

Mobility Training Programs

Finally we believe that federal policy makers should enhance incentives for and encourage institutional cooperation in providing mobility training programs to the mentally retarded and visually impaired.

Travel training offers a number of strong advantages. First, it relieves pressure on specialized transportation systems which in a number of jurisdictions devote a substantial proportion of their capacity to carrying the developmentally disabled. The implementation of effective travel training programs in cities such as Milwaukee could mean that while eligiblity for special services could be broadened to include that minority of the blind or retarded which required them, most members' travel needs could be met by fixed route transportation. The second decided advantage of such programs is their mainstreaming effect; resulting in increased self esteem and eliminating discriminatory attitudes. Moreover, training can be accomplished relatively economically (the typical range for initial training is $500-700) and has had a high level of success.[1]

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[1] The following percentages of clients were successfully trained under several existing programs: 99 percent by the Center on Mental Retardation of Los Angeles in the first year; 99 percent during the first year of the Mobility Training Program in Sacramento; 85 percent by the New York City Board of Education between 1972 and 1982; 72 percent during the first year by the Wayne County Association for the Retarded in Detroit. See, J. Starks, C. Simpson, and H. Menninger, "The Mobility Training Program of Sacramento: Costs and Methods of Teaching Persons with Mental Retardation to Use Fixed-Route Transit." Draft paper, 1983, cited in NCHRP Cost Effectiveness of Transportation Services for Handicapped Persons.

A NON-COMPENSATORY AND CONSTRAINTS ORIENTED APPROACH TO THE TRAVEL BEHAVIOR OF THE ELDERLY AND HANDICAPPED*

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I. INTRODUCTION

The study of choice behavior in urban areas has been the subject of some investigation in the recent transportation literature. The process of travel mode choice behavior has been a specific focus of attention. Two important findings have emerged on individual urban travel behavior. First, many early axioms of disaggregate travel behavior models are unrealistic. The decision process in travel mode choice is increasingly viewed as non-utility maximizing and non-compensatory (Burnett, 1978). Second, structural, societal, and institutional constraints affect travel mode behavior by (i) limiting the choice set, (ii) molding the formation of attitudes and preferences, (iii) inducing choices not in conformity with preferences, and (iv) preventing choice actualization (Burnett & Hanson, 1979; Desbarats, 1983).

Non-compensatory and constraints oriented approaches to travel behavior have been studied for an urban automobile oriented population, as opposed to subgroups with severe travel constraints (Timmermans, 1983). One subgroup which has received attention is the urban elderly and physically handicapped (Parolin, 1982; Gauthier and Parolin, 1983). While this group faces many constraints to urban travel, the additional constraint of physical disability has been studied relative to (i) travel mode perceptual and preference formation, (ii) inducing travel choices not in conformity with preferences, and (iii) travel choice decision strategies. The role of physical barrier constraints in the travel mode choice behavior of the elderly and handicapped has been linked with non-compensatory and non-utility maximizing behavior.

This paper reports on research in which the non-compensatory versus compensatory and constraint oriented approaches to travel behavior have been adopted in understanding the transportation problems of the urban elderly and handicapped. The major objective of this research is the development and estimation of disaggregate travel demand models for the elderly and handicapped which incorporate the effects of physical barrier constraints, travel mode choice decision strategies and processes.

The purpose of these objectives is to understand the components of travel demand by the elderly and handicapped in the context of reduced mobility, accessibility, and spatial interaction. Knowledge of the interactions between physical barrier constraints, choice rules, and choice processes is useful information to policy makers and transit managers alike. This knowledge should enable decision makers to identify the components of a responsive and equitable transportation system for the elderly and handicapped. In addition, it should enable more accurate forecasts of demand for travel services by the elderly and handicapped.

II. LITERATURE REVIEW

Although the literature on the transportation problems of the elderly and handicapped is substantial, there are only a few studies which stress the relationships between physical barrier constraints and processes of travel mode choice behavior. For example, the research by Gauthier (1980) has identified travel mode attributes and their corresponding service levels which contribute most to the constrained elderly and handicapped's perceptual evaluation of the transportation system in Central Ohio. Perceptual evaluation was determined to consist of five dimensions identified as difficulty of travel, convenience, flexibility, safety, and comfort.

Preferred attributes on the difficulty of travel dimension were distance to the vehicle, and assistance to a service pick-up point. The preferred attributes of convenience were identified with the type of vehicle being used. In terms of the flexibility of dimension, the sample displayed preferences for control over route scheduling. Preferred attributes of safety and comfort dimensions were limited seating capacity, ability to restrict number and types of passengers, and the provision of seatbelts, grabrails, and wheelchair locks. Preferred attributes across the dimensions demonstrate that the elderly and handicapped's physical constraints lead to a concern with accessibility in the travel environment and a minimal effort in the use of travel modes.

Early consideration of the effects of physical barrier constraints on travel mode attribute importance and preference is represented in the research of Falcocchio _et_ _al_. (1975) and Miller (1976). A more behavioral and attitudinal approach to the effects of physical barrier constraints on travel mode choice behavior is the research of Parolin (1982). Several findings are relevant to this research. First, market segments were identified for a sample population. For each segment there was identified a distinctive set of travel mode cognitive dimensions. The attribute components of these dimensions were shown to vary across market segments and to reflect the effects of physical barrier constraints. Second, it was found that physical barrier constraints are influential in the formation of travel mode cognitive perceptions, travel mode preferences, and in inducing travel choice not in conformity with preferences.

A significant finding was the evidence of non-compensatory behavior and of simplification in the process of travel mode choice. Among the market segments, only a minimal number of attribute screening criteria are of importance in the dimensions adopted to discriminate between travel modes. Not all attributes are evaluated in the choice process. The attributes of importance reflect a need to overcome physical barrier constraints. Travel modes able to satisfy the screening criteria are selected while others are not.

These findings have implications for the modeling of travel demand among the elderly and handicapped. They suggest that disaggregate travel demand models should include non-compensatory and non-utility maximizing choice structures if actual choice is to be replicated. More importantly, it suggests that demand models should include market segmentation to capture the effects of physical barrier constraints in defining the components of travel mode choice. Although several useful studies have utilized modeling frameworks to forecast demand for travel services by the elderly and handicapped, they lack a conceptual framework which incorporates the components and postulates of disaggregate travel demand models (Knighton and Hartgen, 1977; Lago and Burkhardt, 1980).

On the other hand, disaggregate travel demand models have witnessed a proliferation of use in recent years (Recker and Golob, 1976; Recker and Steven, 1977; Koppelman and Pas, 1980). The random utility multi-nomial logit model (MNL) is most often used to estimate modal split for different urban population groups. The assumptions about travel behavior in the MNL model are well known, and Burnett (1980) provides a critical review of the axioms of current choice models and proposes reconceptualizations of movement behavior postulates.

One set of behavioral assumptions in the MNL model requires the individual to integrate a large amount of information. This does not necessarily correspond to the evidence from psychology that individuals maintain a discriminal function of limited dimensionality (Edwards, 1957). McGuire (1973) has observed that evaluation on the basis of a large set of factors is difficult, given limited human information processing abilities, and can only lead to cognitive overload. Nor does it concur with evidence for the elderly and handicapped (Parolin, 1982).

Further criticisms of compensatory and utility maximizing behavior lend support to the objectives of this research. For example, Wright (1975) has indicated that the evaluation or integration of multi-attribute options occurs through simplifying procedures as opposed to optimizing procedures. As simplifiers, consumers display limited trade-off (compensatory) behavior and opt for non-compensatory strategies. Einhorn (1970) suggests two non-compensatory strategies in information integration. In a disjunctive model, the consumer displays a preference for any mode possessing more than a minimum level of salient travel mode attribute. In a conjunctive model, any travel mode alternative not possessing a certain minimum level of a salient attribute is rejected.

Another non-compensatory and simplistic selection process is lexicographic choice (Tversky, 1972). It assumes that the consumer selects the single most important attribute on which to compare choice set alternatives. From the three choice strategies mentioned, it is clear that individuals may simplify the choice process by reducing cognitive overload. These alternate choice strategies have been shown to be important in travel choice decisions (Foerster, 1979; Recker and Golob, 1979).

III. RESEARCH METHODOLOGY

A questionnaire survey sponsored by the Central Ohio Transit Authority (COTA) was administered to 800 elderly and physically handicapped individuals in the Columbus urban area. Information supplied by 1~~7~~33 respondents form the basis for the travel demand modeling analysis.

The questionnaire includes six different travel modes available in the Columbus urban area. Included were those modes which cater specifically to the travel needs of the physically handicapped. The modes are: automobile, auto passenger, taxi (personal payment), Project Mainstream taxi service, fixed route bus (COTA), and Project Mainstream van service. Project Mainstream taxi service is utilized by qualified elderly and handicapped individuals; the cost is subsidized by COTA. Project Mainstream, a special van service for the elderly and handicapped, has been operational since 1978. Operated by COTA, it requires twenty-four hour notification, provides curb-to-curb service, is wheelchair lift equipped, and offers subscription service.

Physical barrier constraints among the sample were used as a basis for market segmentation. Twelve types of constraints are used in the market segmentation approach (Table 1). Each disability affects individual capabilities to perform physical functions. Of necessity, each reduction in physical restriction will not only limit individual physical activity in travel, but limit the spatial extent of travel itself. This research treats physical constraints both as a barrier to movement and a variable affecting market segment evaluations of travel mode attributes and choice decision strategies.

A. COMPENSATORY CHOICE MODEL:

The MNL used in this research is a random utility model having the following form:

TABLE 1: Physical Barrier Constraints Used for the Research

1. Must stay in bed all or most of the time.
2. Must stay in house all or most of the time.
3. Severe difficulty in climbing stairs (need assistance).
4. Minor difficulty in climbing stairs (no help needed).
5. Need some special aid such as a wheelchair.
6. Difficulty in walking to curb or bus stop.
7. Difficulty in standing.
8. Problems with being in a crowd.
9. Serious visual impairment.
10. Serious hearing impairment.
11. No serious problem in standing or walking.
12. No serious restrictions affecting use of the transportation system.

$$Pi\ (j/m) = \frac{\exp^{V_{ij}}}{\sum_{i=1}^{n} \exp^{V_{im}}} \qquad (1)$$

where Pi(j/m) is the probability of individual i selecting mode j given m available alternatives and n attributes.

Assumed in the structure of the MNL model is the postulate of utility maximization and compensatory behavior. The algebraic formulation of this conceptualization is present in the utility function of the MNL model

$$V_{ijk} = a_o + \sum_{k=1}^{n} B_{ijk} * I_{ik}$$

where B_{ijk} = the importance of attribute k to individual i for mode j; I_{ik} = the individual's level of satisfaction associated with attribute k; and n = the number of important attributes.

The Maximum Likelihood Estimation (MLE) technique is used to estimate parameters (beta coefficients) for selected attributes in the specified MNL model. Two measures are employed to determine how well a compensatory MNL model structure has simulated travel mode choice among the sample population and identified market segments. The first is the Coefficient of Determination (p^2) developed by McFadden (1974). This measure is analogous to the multiple correlation coefficent and is given as follows:

$$p^2 = 1 - \frac{L\ (\theta)}{L\ (0)} \qquad (2)$$

where L (θ) = log likelihood for the vector of estimated parameters θ, and L (0) = log likelihood for all model parameters set equal to 0. The p^2 value ranges between zero and one, with higher values denoting better goodness-of-fit.

A second measure is termed the Percentage Correctly Estimated (PCE). The PCE statistic measures the proportion of individuals whose modal choices are correctly derived from the MNL model.

B. NON-COMPENSATORY CHOICE MODEL:

For the non-compensatory analysis, a modified random utility MNL model is utilized (Chou, 1983). The model first calculates estimated travel mode preference rank order (P_i) by comparing relative preferences rank orders (RP_i) to a selected base mode z,

$$P_i = \frac{RP_i}{RP_i + RP_z} \quad (3).$$

Second, the model relates preference, P, to satisfaction value, V, through a binary MNL model,

$$P_i = \frac{1}{1 + \exp \sum_{i=1}^{n} B_j (V_{zj} - V_{ij})} \quad (4)$$

where B_j = the parameter of relative weight of the difference in attribute satisfaction; V_{ij} = satisfaction level of mode i with respect to attribute j; $(V_{zj} - V_{ij})$ = the difference in attribute satisfaction. Parameter values (B_j) in this model are not estimated using MLE methods but instead are estimated using Ordinary Least Squares (OLS) methods (Domencich and McFadden, 1975). The resulting beta values, or estimated attribute importance indices, are then used as input to the next modeling stage - the evaluation of non-compensatory strategies.

(i) Lexicographic Choice - in the modified MNL model a travel mode is selected by this strategy only if the following two conditions are met:

$$V(ij) = \max\ (i=1,\ m)\ V(i,j) \tag{5}$$

$$B(j) = \max\ (j=1,\ n)\ B(j) \tag{6}$$

(ii) Conjunctive Choice - a travel mode is selected by this strategy in the model such that,

$$V\ (i,j) = \min\ (i=1,\ m;\ j=1,\ n)\ V(i,j) \tag{7}$$

(iii) Lexocon Choice Strategy - the lexicon model was developed by Chou (1983) to eliminate the problems associated with the conjunctive and lexicographic choice strategies. The Lexicon model requires that a mode be eliminated from the alternatives if the following conditions are met:

$$B_j \left| V_{ij} - V_{zj} \right| = \mathrm{Max}(j=1,\ n)\ (B_j \left| V_{ij} - V_{zj} \right|) \tag{8}$$

$$V_{ij} = \mathrm{Min}\ (i=1,\ m)\ \ (V_{ij}) \tag{9}$$

This model sequentially eliminates alternatives according to the most important difference in satisfaction level. The differences in satisfaction are weighted by attribute importance.

Since the non-compensatory MNL model is a modified version of the random utility compensatory model, one is not able to compare goodness-of-fit using the p^2 value - as the former is not estimated by MLE methods. Goodness-of-fit can be compared by the PCE statistic - a measure of the forecasting accuracy of the model.

In summary, the methodology in this research focuses on a compensatory and non-compensatory MNL analysis. For both strategies, travel demand models are generated and compared for the larger sample population and for identified market segments.

IV. RESEARCH RESULTS

Table 2 lists the socio-economic and travel related characteristics of the elderly and handicapped sample population. The profile is one of a population which is predominantly female, likely to be unemployed or retired, and residing in private dwellings or apartments. Travel characteristics indicate the auto passenger as the primary mode of private transportation (48.1%) among the sample. Project Mainstream services are the primary modes of public transportation (81.2%) among the sample. Trip frequency statistics indicate relatively infrequent travel by the sample population. Most make one or two trips per week to visit a doctor, purchase food, or attend senior citizen functions. Medical trips are the most important (67.6%).

Travel preferences are overwhelmingly for public modes (Project Mainstream services) which are demand responsive, provide curb-to-curb service, and are low cost. The auto-passenger, which is the most frequently used mode, is the third most preferred travel mode. This indicates that for many of the sample population their actual choice is not in conformity with their preferences.

Table 3 indicates that the sample population faces multiple physical barrier constraints. The most common are difficulties in standing, walking to a curb or bus stop, and climbing stairs. A small percentage (16.5%) are either wheelchair confined or need some special aid such as a wheelchair. Those with hearing or visual impairment are able to use most modes of transportation. The first, third, and seventh categories indicate that a large portion of the sample (73.0%) have either no restrictions or very minor restrictions affecting their use of the transportation system. These individuals possess the physical capability to travel, but do not travel

TABLE 2: Socio-Economic and Travel Related Characteristics of Sample Population

	Percentage
Age:	
18-25	27.8
26-35	9.0
36-45	9.0
46-55	12.7
55-65	26.3
Over 65	33.8
Sex:	
Male	35.6
Female	64.6
Dwelling:	
House	45.1
Apartment	39.8
Nursing Home	1.5
Retirement Center	9.7
Motel/other	3.7
Employment:	
Unemployed full-time	8.2
Unemployed	22.5
Retired	44.3
Employed part-time	3.7
Homemaker	20.3
Travel Modes Frequently Used:	
Auto Passenger	48.1
Auto Driver	7.5
Taxi (Personal Payment)	17.2
COTA (Regular Bus)	23.3
Project Mainstream Van Service	40.6
Project Mainstream Taxi Service	40.6
Trips Per Week on Most Frequently Used Mode:	
0-1	26.3
2-3	27.8
4-5	9.7
6-7	4.5
8-9	4.5
10 or more	12.0
None	11.2

TABLE 2 (Cont'd)

	Percentage
Trip Types	
Work	16.5
Education	12.0
Medical	67.6
Shopping	39.0
Personal Business	27.0
Personal Pleasure	28.5
Travel Mode Preferences:	(%)
Auto Passenger	30.8
Auto Driver	13.5
Taxi (Personal Payment)	10.5
COTA (Regular Bus)	24.8
Project Mainstream Van Service	45.1
Project Mainstream Taxi Service	49.6

TABLE 3: Physical Barrier Constraints of the Sample Population

Physical Barrier Constraint	Percentage
No serious restrictions affecting use of the transportation system	25.50
Need some special aid such as a wheelchair	16.54
No serious problems in standing or walking	8.20
Difficulty in standing	57.89
Difficulty in walking to curb or bus stop	59.39
Severe difficulty in climbing stairs (need assistance)	36.80
Minor difficulty in climbing stairs	29.32
Serious visual impairment	24.90
Problems with being in a crowd	18.79
Serious hearing impairment	9.70
Must stay in bed all or most of the time	3.00
Must stay in house all or most of the time	17.29

frequently because of age and driver license constraints. It is anticipated that this group will possess a different choice structure and a diverse set of attributes in comparison to other individuals in the sample.

To identify market segments, Wards (1964) HGROUP clustering algorithm is used. The criteria for determining the number of market segments are the types of physical constraints possessed by the sample population. Table 4 presents selected characteristics of the three internally homogeneous market segments which are defined as

Group 1: No Serious Restrictions
Group 2: Minor Restrictions
Group 3: Wheelchair Users.

Of note is the similarity of each segment's situational profile to that of the larger sample. The three market segments are also representative of the diversity in travel needs, physical constraints, and orientation to travel modes. This diversity indicates that attributes of importance to respective market segments will vary. When these attributes are used to simulate travel demand, it is expected that the choice strategies and goodness-of-fit statistics will vary. In addition, the effects of physical constraints on choice strategies and travel behavior are expected to be defined through market segmentation.

A. COMPENSATORY MNL MODEL RESULTS:

Table 5 indicates the results of the compensatory MNL analysis for the sample population. A travel demand model using a compensatory structure is not able to simulate travel mode choice among the immobile sample population. This implies that trade-off behavior is not part of the decision strategy among the sample population; they are not utility maximizers.

TABLE 4: Characteristics of Identified Market Segments

	Percentage		
	1	2	3
	N - 37	N - 72	N - 24
Age:			
18-25	8.1	4.1	20.8
26-35	13.5	2.7	20.8
36-45	5.4	11.1	8.3
46-55	16.2	12.5	8.3
55-65	24.3	27.7	25.0
Over 65	29.7	41.6	16.6
Sex:			
Male	48.6	25.0	45.8
Female	51.3	75.0	54.1
Dwelling:			
House	48.6	45.8	37.5
Apartment	37.8	34.7	58.3
Nursing Home	5.4	—	—
Retirement Center	2.7	15.2	4.1
Motel/other	5.4	4.1	—
Employment:			
Employed Full-Time	10.8	6.9	8.3
Employed Part-Time	13.5	—	—
Unemployed	18.9	22.2	29.1
Retired	56.7	69.4	62.5
Travel Modes Frequently Used:			
Auto Passenger	45.9	45.8	58.3
Auto Driver	10.8	4.1	12.5
Taxi (Personal Payment)	27.0	13.8	12.5
COTA (Regular Bus)	40.5	20.8	4.1
Project Mainstream Van Service	40.4	38.8	45.8
Project Mainstream Taxi Service	37.8	45.9	33.3
Trips Per Week on Most Frequently Used Mode:			
0-1	18.9	30.5	25.0
2-3	27.0	29.1	25.0
4-5	16.2	8.3	4.1
6-7	8.1	2.7	4.1
8-9	5.4	2.7	8.3
10 or more	13.5	11.1	20.8
None	10.8	11.1	12.5
Trip Types:			
Work	27.0	11.1	16.6
Education	16.2	5.5	25.0
Medical	56.7	75.0	62.5
Shopping	45.9	33.3	45.8
Personal Business	37.8	20.8	29.1
Personal Pleasure	37.8	16.6	50.0

TABLE 5: Compensatory MNL Results: Goodness-of-Fit
(Sample Population)

	Attributes			
	Suitability	Assistance	Friendly and Courteous Drivers	Sensitivi Understa
Parameter Values	0.0589	-0.11	0.01067	0.04
T-Statistic	0.6212	-2.0590*	0.1194	0.53

*Significant at the 0.05 level

$L(0) = -237.4$

$P^2 = 0.00377$

PCE = 0%

The inability of the compensatory MNL model to simulate travel mode choice is consistent with apriori expectations. From previous discussion, it is evident that any travel demand analysis for the elderly and handicapped should consider alternatives to compensatory MNL models. The travel mode choice process of the elderly and handicapped has been shown to, (i) be defined by physical constraints, and (ii) vary according to market segments based upon physical constraints. This heterogeneity must be treated in any travel demand analysis through market segmentation. Given these expectations, one would not anticipate statistically meaningful results from the compensatory model.

The next stage involves calibrating MNL travel demand models for each market segment. Model estimation and goodness-of-fit statistics for the three market segments are shown in Table 6. The market segmentation approach yields somewhat better results. Note for the no restrictions segment, the results do indicate the presence of some compensatory behavior. This market segment is not constrained by physical barriers to a limited screening criteria nor to simplification in the mode choice process. Some compensatory behavior involving a very limited number of attributes is even evident for wheelchair users. The importance of two attributes indicates simplification in the choice process. Trade-offs among the two attributes are most likely to occur for the auto-passenger and Project Mainstream service modes.

Despite improved model performance with segmentation, the predictive power is too low for valid estimates. In addition, the significant attributes in the models cannot be interpreted to represent ideal components of a transportation system for the elderly and handicapped.

TABLE 6: Compensatory MNL Results: Goodness-of-Fit

No Serious Restrictions Segment

Attributes	Cost	Convenience	Comfort	Privacy	Assistance
Parameter Values	-0.2428	-0.3540	0.1999	-0.3881	0.1279
T-Statistic	-1.3468	-1.8096*	1.1160	-2.0766*	0.5829

*Significant at the 0.05 level

L(0)= -59.07 p^2= 0.10887 PCE= 10.8%

Minor Restrictions Segment

Attributes	Privacy	Personal Nature of Travel Modes
Parameter Values	0.1192	0.2712
T-Statistic	-1.0261	2.4529*

*Significant at the 0.05 level

L(0)= -125.95 p^2= 0.02365 PCE= 1.38%

Wheelchair Users Segment

Attributes	Comfort	Assistance
Parameter Values	-0.4928	-0.6465
T-Statistic	-2.3076*	-2.3886*

*Significant at the 0.05 level

L(0)= -31.13 p^2= 0.27601 PCE= 29.16%

B. NON-COMPENSATORY MNL MODEL RESULTS:

Table 7 presents results from the non-compensatory demand models. Several conclusions are evident. First, the PCE statistics indicate non-compensatory decision strategies out-perform the compensatory strategy in mode choice behavior: the non-compensatory models predict mode choice more accurately than the compensatory model. Second, the convenience and assistance attributes are the most important criteria for the sample population.

A third finding is that the lexicographic decision strategy model is the most accurate predicter of mode choice. It is important then to consider the relationships between a lexicographic decision strategy, physical barrier constraints, and the attributes of importance. The importance of the convenience attribute is related to, (i) the need to reduce the burden of travel, and (ii) the importance of easy access to travel modes. This is significant given the debate over mobility versus accessibility for the elderly and handicapped. Clearly, the sample population has opted for access and convenience. Their diverse physical constraints demand the ability to move from residence to a travel mode with minimal effort. Of equal importance is the need for assistance in getting on and off a vehicle. This attribute expresses the desire to overcome physical barrier constraints in using travel modes.

Without easy access to a travel mode and some form of assistance, the possibilities for satisfying needs and requirements are limited. For these reasons, a lexicographic choice strategy predominates among the sample population. Two travel modes, the auto-passenger and Project Mainstream taxi service, meet the limited screening criteria of the sample population very

TABLE 7: Non-Compensatory MNL Model Results

Sample Population

	Compensatory	Lexicographic	Conjunctive	Lexicon
PCE (%)	0%	26%	20%	22%

Attributes:
1. Convenience
2. Assistance

No Serious Restrictions Segment

	Compensatory	Lexicographic	Conjunctive	Lexicon
PCE (%)	10.8%	0%	22%	11%

Attributes:
1. Suitability
2. Assistance
3. Friendly and Courteous Drivers
4. Sensitivity and Understanding

Minor Restrictions Segment

	Compensatory	Lexicographic	Conjunctive	Lexicon
PCE (%)	1.3%	20%	20%	20%

Attributes:
1. Cost
2. Convenience
3. Comfort
4. Privacy
5. Personal Nature

Wheelchair Users Segment

	Compensatory	Lexicographic	Conjunctive	Lexicon
PCE (%)	29.1%	18%	55%	27%

Attributes:
1. Convenience
2. Assistance

successfully. This important finding suggests that in an ideal transportation system for the elderly and handicapped, the minimum requirements are high levels of convenience and assistance.

Table 7 shows results from a series of non-compensatory MNL models for identified market segments.

No Serious Restrictions Segment: The conjunctive choice model indicates the highest percentage of correct estimations. For a market segment which possesses no serious restrictions in using travel service, a conjunctive choice strategy is conceptually sound because individuals evaluate more attributes and establish a psychological threshold level. The relative absence of physical constraints also allows a perceptual structure which is more concerned with effort in travel. For this reason, travel burden is viewed as requiring, (i) a friendly and courteous driver, (ii) a suitable travel mode, and (iii) the psychological satisfaction that assistance is available if required.

Minor Restrictions Segment: For this market segment the non-compensatory choice model predicts choice more accurately than a compensatory model. All three non-compensatory choice strategies perform equally well in the simulation of travel choice.

Attributes of cost, convenience, comfort, privacy, and personalized service are more similar to those of a mobile than immobile population. With only minor restrictions, this segment is able to utilize modes providing higher levels of mobility. Thus it does not need to be as concerned with those attributes which overcome physical constraints. Non-compensatory models for this segment suggest an ideal transportation system would be composed of attributes associated with high quality of service. Existing travel services are available to meet the needs of this segment. Project Mainstream services and the auto-passenger travel modes are demand responsive services which they perceive as providing a high quality of service.

Wheelchair Users Segment: A conjunctive MNL model shows the highest percentage of correct estimations. Attributes of importance in the non-compensatory analysis correspond to those of the compensatory analysis. The attributes of comfort and personal assistance are important criteria by which travel modes are evaluated. The perceptual concern with comfort and assistance is an attempt to minimize both physical and travel constraints in the process of travel. Travel modes perceived to possess these important attributes are Project Mainstream Van Service and the auto-passenger mode.

Finally, the wheelchair users do not appear to be as concerned with access, or mobility, in travel as the other segments because most wheelchair users have several alternatives in their choice set. In most cases, access to the vehicle is overcome through a wheelchair lift equipped feature. The predominant concern among the wheelchair users is with the quality, effort, and comfort in travel.

A comparison of results between the compensatory and non-compensatory models reveals that mode choice behavior among the elderly and handicapped sample population is, as expected, best characterized as being non-compensatory. The analysis also shows that physical barrier constraints do affect mode choice behavior and decision strategies. The effects of physical barrier constraints are highly evident in the presence of, (i) variations in attributes which compose non-compensatory models, and (ii) variations in choice decision rules.

The attribute composition of the models serves to highlight the sample population's perception of an ideal transportation system. In general, there is a strong preference for demand responsive systems that offer a high level of service. Comfort, convenience, assistance, privacy, and personalized service, etc., are attributes of importance. For several market segments these attributes represent strong psychological concerns for, (i) access to travel modes, and (ii) minimal effort in travel.

V. SUMMARY AND POLICY IMPLICATIONS

Several of the conclusions from this research have policy implications for the elderly and handicapped. The strong characteristics of non-compensatory travel mode choice behavior by the sample population lends support to recent evaluations of the postulates underlying travel mode choice behavior. The sample population are simplifiers in the decision process and non-utility maximizers in the final choice process. The important implication is that travel demand analysis (modeling) for the elderly and handicapped should be based upon postulates of non-compensatory behavior. In forecasting future demand for travel services designed for the elderly and handicapped, transit or planning agencies should utilize non-compensatory MNL models.

Further justification for utilizing non-compensatory models relate to other conclusions. Physical barrier constraints, as reflected in the market segments, define the attributes of perceived importance in travel mode choice. Thus, physical barrier constraints permeate the entire process of travel mode choice behavior. Developing non-compensatory models for each segment would allow planners and policy makers to, (i) disaggregate a heterogeneous group into segments based upon their ability to use travel facilities, (ii) target travel service improvements to particular segments, or to a larger group, and (iii) evaluate the perceived attributes of importance in forecasting demand.

It is also evident that the elderly and handicapped sample population perceive access to travel services as an important consideration in mode choice decision making. This concern is a function of their physical barrier constraints. A preoccupation with mobility is not apparent among the sample. Thus access to travel services is one important area that should be examined by policy makers and planners. The attributes of importance for the sample, in terms of accessibility, are personal assistance, sensitivity and understanding, friendly and courteous drivers, and travel mode comfort.

The prevalence of accessibility concerns among the elderly and handicapped sample brings into question what is an 'ideal' transportation system. Although accessibility concerns predominate, the elderly and handicapped do not perceive the need for a radically different transportation system in Columbus, Ohio, to meet their needs and requirements. For the travel services which provide mobility for the elderly and handicapped, the findings show the sample to be satisfied with current demand responsive services. High preference and mode usage statistics for Project Mainstream van and taxi services, COTA regular bus, and the auto-passenger are indicative of 'ideal' travel services.

It can be concluded that an 'ideal' transportation system is perceived to be present and operational in Columbus, Ohio. However, the elderly and handicapped sample perceive improvements to be necessary in those attributes which enhance their accessibility to travel services.

Transit planning agencies must also realize that the elderly and handicapped population which they serve is a heterogeneous one. There exists much variation in their physical barrier constraints, travel needs and travel requirements. Only when this heterogeneity is clearly defined can transit agencies implement appropriate policies to reduce the burden of travel, and improve overall accessibility.

Plans for travel services for the elderly and handicapped should, therefore, be based upon clearly defined market segments. These market segments should, in turn, be based on the types of physical barrier constraints. Two reasons make this necessary: (i) physical barrier constraints determine the ability to travel and (ii) they define perceived attribute importance, non-compensatory decision strategies, and actual travel mode choice. Physical barrier constraints should be the basis for providing services to meet respective travel needs and requirements of different market segments. This will ensure that more equitable levels of travel service are provided to all the elderly and handicapped.

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MONITORING THE TRIALS OF A PROTOTYPE TAXI ACCESSIBLE TO DISABLED PEOPLE

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1. INTRODUCTION

1.1 Background to the project

In recent years there has been an increasing awareness of the transport problems faced by disabled people in the UK. As a consequence, efforts have been made by both central and local governments and by transport operators to make transport systems more accessible to people with a wide range of disabilities. The Department of Transport (DTp) initiated a number of projects along these lines during 1981, The International Year of the Disabled. One of these involved participation with Carbodies Limited in the design and development of a new taxi-cab.

Carbodies manufacture the FX4 black London cab and were, at the time, designing a replacement model, code-named CR6. During discussions with the DTp and its Transport and Road Research Laboratory (TRRL) the design of the CR6 was modified to improve its capability to accommodate disabled passengers whilst seated in their wheelchairs. The DTp purchased two "prototype" vehicles from Carbodies with the intention that they be subject to extensive field trials.

The term prototype is used here to describe the two vehicles subject to trial although it must be stressed that they were not engineering prototypes in the conventional sense. They are more properly described as factory mock-ups which were converted into running vehicles because the DTp were keen to obtain early experience in transporting disabled people in taxis, under a variety of operational modes. These two vehicles preceeded those constructed to test engineering aspects, such as suspension design or choice of engine, and gave only a preliminary idea of the engineering package.

The Transport Operations Research Group (TORG) and the Design Unit of the University of Newcastle upon Tyne were commissioned by TRRL to monitor the field trials of the vehicles and to evaluate the design of the prototypes, with particular reference to their use by disabled people. TRRL placed four operating contracts for the two vehicles during the period May 1982 to mid 1984. This paper presents some of the results of those trial operations.

1.2 The operating contracts

The four placements and the periods over which data were collected and reported upon here are:

for Prototype 1 - Community Transport, Newcastle upon Tyne:
11 May 1982-30 May 1983; and
Potteries Motor Traction, Stoke on Trent:
20 July 1983-31 December 1983; and
for Prototype 2 - Boulton's Peterborough Taxis, Peterborough:
26 July 1982-31 May 1983; and
Edinburgh Cripple Aid Society/Radiocabs, Edinburgh:
29 September 1983-31 December 1983.

The four operating contracts are referred to as the Newcastle, Peterborough, Stoke and Edinburgh placements, respectively. There were only small physical differences between the two prototype vehicles which can be discounted for the purpose of this paper.

The first operator is a registered charity, providing transport to disadvantaged groups and the CR6 was used in Newcastle almost wholly to transport disabled people. Boulton's Taxis is a small commercial taxi operation whilst Potteries Motor Traction (PMT) is a National Bus Company subsidiary which uses a small number of taxi-cabs to provide a Flexibus service. The Edinburgh placement is to a charity providing transport facilities to certain groups of people, with the vehicle being operated by a commercial taxi operator.

The operators were to operate the vehicle, provide qualified drivers, and be responsible for financial management. Records were to be kept of the use made of the vehicle, the costs of using it and the revenue earned. Although ownership of the vehicle remained with the Department of Transport, the vehicle was provided to be used by the operator "as though it was owned by them". This was to "include use wherever possible by people with a wide range of disabilities". It was intended that the operators use the vehicles according to their respective commercial criteria.

2. AIMS AND OBJECTIVES

There were two main aims of the monitoring:

(a) to evaluate the design of the prototype CR6 for use by disabled people; and

(b) to examine the operational performance of the prototype vehicles.

A subsidiary aim was to produce guidelines for the designers of other vehicles intended for use by disabled people.

It is important to remember that the basic purpose of the vehicle is as a taxi to transport able-bodied persons. The field trials summarised here, and the aspects highlighted in the report, represent conditions far from typical of those which the production vehicles generally will face. In normal taxi-cab operation, disabled passengers will be few and far between.

Specific objectives for the research programme were defined as:

(1) to evaluate the design of the CR6 for use by disabled people;
(2) to review the practical problems encountered by disabled people in using small vehicles;
(3) to produce guidelines for the design of small vehicles which are intended for use by disabled persons;
(4) to evaluate the operational performance of the prototypes, with particular reference to costs and patterns of use;
(5) to determine the travel patterns of those who make use of the prototype vehicles; and
(6) to report on the findings.

These will be reported in full in due course. This paper is mainly concerned with objectives (4) and (5). It also discusses the problems of data collection and the value of the trials.

3. METHODS OF DATA COLLECTION

3.1 Framework

Data collection had two major elements, field observations of the performance of the prototypes under real operating conditions and controlled experiments where a range of conditions were simulated and the response of volunteer users were noted. The first element provides the main source of information for the operational evaluation, the second element contributes to evaluating the design for use by disabled persons.

Figure 3.1 illustrates the various sources of information which were established and which provide the data for this report.

FIGURE 3.1 Framework of data collection

Source of information / Type of data (relevant objective numbers given in brackets)	Controlled experiments	Field observation	Interviews of users	Questionnaire survey of users	Operating records - completion by drivers	Operating records - completion by management	Interviews of drivers	Interviews of managers	Household interview in North Tyneside
Ergonomic (1)(2)(3)	✓✓	✓✓	✓	✓	✓	✓	✓	✓	✓✓
Travel patterns and attitudes of users (1)(2)(3)(4)(5)	✓	✓✓	✓✓	✓			✓	✓	
Usage (2)(3)(5)		✓	✓✓	✓✓	✓	✓			
Operating performance costs (4)					✓	✓✓	✓	✓	
Attitudes of operators (1)(2)(3)(4)(5)					✓	✓	✓✓	✓✓	

Key ✓✓ primary source

✓ secondary source

(1) figures in brackets refer to objectives given in section 2.

3.2 Problems encountered

At an early stage in the project it became apparent that no national data base is available which describes the sizes of wheelchairs in current use in the UK. Further, there was no means of testing the hypothesis that wheelchairs used out of doors differed significantly in size from those used only indoors. Knowledge of the statistical distributions of the basic dimensions of wheelchairs clearly was needed to evaluate the design of the vehicle and to develop the design guidelines required by the project brief. Accordingly the research programme was extended to include a household interview survey, which included measurement of wheelchairs. This was undertaken in the District of North Tyneside (Hall and Silcock, 1984).

Much of the data collection relied upon the vehicles' drivers and the managers of the operating organisations keeping adequate records. In the main this was done satisfactorily in Newcastle, Peterborough and Stoke. However, for the short period of operation in Edinburgh which is covered here, only limited data was collected.

The third area of difficulty arose because of the high proportion of multiple use of the taxi by some passengers. This meant that a significant part of the use of the vehicle was by the same group of people, on a regular basis. The questionnaire survey of users, which was implemented by the drivers, thus was reduced in scale due to the entirely reasonable reluctance of drivers repeatedly to ask the same passengers to complete the same form. It also meant that there were fewer individuals to survey, in total.

3.3 Data available and their limitations

The data are discussed under three broad headings; that is operational data, passengers' views and data of wider relevance for the design of accessible vehicles.

Operational data

Data are available which describe the pattern of use of the vehicles in the context of the different placements. It is thus possible to compare the CR6 with other vehicles in the operators' fleets and to contrast the use made of the vehicles in each placement. However, it is very probable that the pattern of use of the prototypes would not be repeated in the same areas. For example, the owner-manager of the Peterborough taxi firm which operated the CR6 estimated that the one vehicle met the great majority of demand for transporting wheelchair-users in the Peterborough area. Had all taxis in Peterborough been accessible then the pattern of use of a single CR6 would have been very different.

Apart from difficulties encountered with data collection in Edinburgh, the records kept by the operators are felt to be reasonably accurate in describing the use of the vehicle.

Passengers' views

Questionnaire returns are available from wheelchair-users, ambulant disabled passengers and able-bodied passengers. A limited number of passenger interviews also were conducted. These, and the controlled experiments with selected groups of disabled people, revealed an unwillingness to criticise the vehicles. It is probable that this is due to the fact that, for many, the CR6 offered a substantial increase in their opportunities to travel and that set alongside this major benefit any detailed criticism of the vehicle seemed both trivial and carping. If this is so, then the questionnaire returns reflect general approval of the CR6 concept rather than specific comment on the design of the vehicle.

Wider use of the data

The nature of the field trials meant that no attempt could be made to ensure that representatives of the total spectrum of prospective disabled passengers were carried in the vehicles. It is probable that there was bias towards wheelchair-users, as much of the publicity concentrated on this aspect. Even so, there are likely to have been certain disabilities and types of wheelchair which were not encountered in the trials. Similarly, the controlled experiments, which involved taking a prototype to a particular group of disabled people at a day centre or special hospital, are not claimed to have covered all types of disability or category of prospective user. This means that strict statistical comparisons with national data cannot be made and any design guidelines which emerge from the project can only be couched in general terms. One exception to this is the subject of wheelchair dimensions which, because they are critical to the design of accessible vehicles, were established by the special survey referred to in 3.2 above. In this area the data can be discussed in statistical terms with some confidence.

4. USE OF THE PROTOTYPES

4.1 Type of hirings

The different nature of the services provided by the four operators led to substantial differences in the types of hirings which the vehicles undertook in each placement. Table 4.1 illustrates this.

In Newcastle, all hirings from Community Transport were private or contract bookings; 86% of person-trips were booked by the individual travelling, thus the great majority of journeys are classified as private hire.

The two taxi operators used the vehicles in different ways. In Peterborough the CR6 replaced a licensed taxi and its pattern of business broadly reflects the nature of taxi operations by the company concerned; 65% of hirings were made through the despatch office on a private hire basis. In Edinburgh the preferential treatment given to ECAS bookings for their disabled clients reverses the picture, with 81% of hirings being classified as contract hires through ECAS, although most probably are of a private hire nature.

The bus operator in Stoke began an experimental stage carriage basis towards the end of the placements. During the monitoring period this carried few passengers and as Table 4.1 reveals, private hire formed the bulk of the use of CR6 in Stoke.

Overall, therefore, it appears that the major market exploited by all

TABLE 4.1 Type of Hirings

	Newcastle		Peterborough		Stoke		Edinburgh	
	No. of veh-trips	%	No. of veh-trips	%	No. of veh-trips	%	No. of veh-trips	%
On-street or rank hire	N/A	-	1,085	25	N/A	-	89(1)	19
Radio call or telephone bookings for private hire	1,029(1)	100	2,784	65	286	79		
Contract hire pre-booked			409	10	61	17	382	81
Stage carriage	N/A	-	N/A	-	13	4	N/A	-
Total	1,029	100	4,278	100	360	100	471	100

N/A - not allowable in this operation

Source: Operators' records

(1) Detailed breakdown not available

Note: Contract hire generally implies booking 24 hours or more in advance of travel four operators was that of individual journeys on a private hire basis. The passengers' views discussed in section 5 reveal that many of these journeys could not have been made at all in the absence of CR6.

4.2 Utilisation of the vehicles

Summary statistics are presented in Table 4.2. The vehicle carried 10,334 passenger journeys on 6,160 hired vehicle-trips, although it must be noted that well over half of these took place in Peterborough. The mileage figures in Table 4.2 also demonstrate that the CR6 was used most intensively by the commercial taxi operators in Peterborough and Edinburgh.

The reason for this is straightforward and lies in the nature of the operations, as can be seen when the type of passengers carried is examined. Only 12½% of the passenger journeys in Peterborough were by disabled people and only 20% of the hired trips included a disabled passenger. In Newcastle, by way of contrast, all but 3 journeys carried at least one disabled person. In Peterborough the taxi company was using the CR6 as a replacement for a conventional taxi, it thus carried disabled passengers largely in addition to conventional taxi trade whereas in Newcastle, Community Transport were providing a specialist service only to disabled passengers.

Although the CR6 was operated by a taxi company in Edinburgh, it was allocated on a priority basis to trips carrying disabled people and the opportunity for its use by other passengers was limited. Despite this, its overall use in Edinburgh was lower than expected.

During the period monitored approximately 2,070 journeys were made in the CR6's by wheelchair-users and 740 by ambulant disabled passengers. It is clear from these figures that use by disabled people was heavily biased to wheelchair-users, reflecting the nature of publicity for the vehicle and, perhaps, the very limited nature of the alternative means of transport available to this group of people.

4.3 Vehicle occupancy

The highest average occupancies occurred in Stoke and Edinburgh. In Stoke, trips with disabled passengers had an average occupancy of 2.20 (excluding the driver); this fell to 1.25 in Edinburgh, whereas in contrast, trips without disabled passengers had their highest occupancy, 2.20, in Edinburgh. In Peterborough, average occupancy was 1.74 for both categories of journey. No clear picture emerges from these figures, but the Edinburgh occupancy of 1.25 for trips with disabled passengers and the figure of 1.44 for the same category of trips in Newcastle suggest that, where services are provided which cater particularly for disabled people, then a substantial proportion of them travel without escorts.

4.4 Frequency of travel

Studies elsewhere of special transport services for disabled people have revealed a tendency for much of their use to be by a few individuals making many journeys. There was some evidence of this in the CR6 trials. In Newcastle, 30% of person-trips were accounted for by only 4 individuals and in Peterborough one regular contract accounted for 150 person-trips by one individual (16% of disabled passenger journeys). In Stoke, 4 passengers accounted for 34% of private hires and 6 passengers for all 163 contract hires. In Edinburgh 6 passengers made 21% of passenger trips.

TABLE 4.2 Utilisation of the Vehicles

Item	Newcastle	Peterborough	Stoke	Edinburgh	Overall
Total no. of hired vehicle trips	1,029	4,300	360(1)	471	6,160
No. of hired vehicle trips per day in service	4.7	16.8	2.2	8.6	9.6
Total no. of passenger journeys carried	1,446	7,436	790	662	10,334
- wheelchair users	745	803	282	240	2,070
- ambulant disabled	377	124	96	139	736
- able bodied	304	6,505	355	277	7,441
- category not know	20	4	57	6	87
Total no. of miles operated	11,917	37,150	9,156	7,000(2)	65,000(2)
- in revenue service	4,904	17,420	4,578(2)	N/K	N/K
Average no. of miles operated per day in service	53.9	145.1	55.5	143(2)	101(2)
Mean hired trip length (miles)	4.6	4.0	14.75	N/K	N/K

Sources: Placement reports based on operators' records.

(1) including 13 stage carriage journeys.
(2) estimated.

4.5 Operating costs and revenues

The charging structure for the services offered in each placement varied widely. Similarly, so do the costs which can be attributed to the operation of CR6. This is clearly seen in Table 4.3.

Revenue per hired trip reflects the nature of the four operations. CT in Newcastle are a charitable organisation with low costs. They do not seek profits and their charges reflect the low cost structure - hence the lowest revenue per trip was obtained in Newcastle.

In Edinburgh and Peterborough the prevailing taxi fares during the trial periods were:

Peterborough - 80p for the first mile and 50p per mile thereafter
Edinburgh - 86.3p for the first mile and 46.3p per mile thereafter.

When revenues per hired trip are viewed in the light of these similar fare structures, journey lengths in Edinburgh are seen to have been getting on for twice those in Peterborough. This is not implausible, given the size of the two urban areas and that ECAS covers all of the Edinburgh area.

Although the daily trip rate in Stoke was low, those trips which were undertaken earned high incomes, mainly due to the high proportion of long journeys and Flexibus' market pricing policy.

As can be seen from Table 4.3 no allowance is included for the capital cost of the vehicles, which were wholly met by the DTp. Operators met direct fuel and minor maintenance costs, normal insurance charges and, in some cases, drivers' wages. Administrative costs due to the presence of CR6 in the respective vehicle fleets have not been included.

The absence of capital charges resulted in each operator except Radiocabs making a notional profit from operating the CR6's on the terms of the placement contracts.

4.6 Conclusions on operations

The major contribution of the CR6's in the localities in which they were operated was to carry 2070 wheelchair-user trips, the great majority whilst seated in their wheelchairs, for whom such travel had previously been impossible. The four operators clearly demonstrated the practicality of the concept of an accessible taxi in a variety of operating modes although its financial viability was questionable for services other than private hire.

The fact that each CR6 was unique in the areas in which the trials were conducted makes it well-nigh impossible to generalise from the results of the trials to a situation in which many more similar vehicles were operating in the towns concerned. In such circumstances, for conventional taxi operations, disabled passengers probably would form a very small part of the business as a whole.

For operations such as Community Transport, whose aims are to serve disadvantaged groups such as wheelchair-users, it is likely that the role of a CR6 type of vehicle would depend very much on how it were to be financed. Providing a very personalised service is costly, compared with group services via a minibus, and the scope for small vehicles probably is limited in such organisations.

TABLE 4.3. Summary of Costs and Revenues

	Newcastle	Peterborough	Stoke	Edinburgh (5)
Total Revenue (£)	1,404	9,402	2,560	1,390
Revenue per hired trip (£)	1.45	2.19	7.11	4.01
Fuel and minor maintenance costs (£)	851	1,922	592	810
Insurance (£) (1)	430	400	13	100
Drivers' costs (£)	nil (2)	2,821 (3)	1,200 (4)	551 (3)
Total costs incurred by operator (£)	1,281	5,143	1,805	1,461

(1) standard cost to operator; additional cost due to prototype nature of vehicle met by DTp.

(2) met by MSC schemes, or volunteer drivers.

(3) allowance of 30% of revenue; standard practice in the firm concerned with self-employed drivers.

(4) estimated

(5) for Radiocabs Ltd.

Sources: operators' records.

The limited experience gained from the experimental stage-carriage service in Stoke is that it is not a realistic proposition to operate a stage-carriage service for disabled people with a small vehicle. The reasons for the very low use of the service are not, however, clear from the limited monitoring which was possible.

5. PASSENGERS' VIEWS

5.1 Data sources

The primary sources of data for this section are self-completion questionnaires issued to users of the taxis during each placement.

Three similar questionnaires were used at each location, intended for completion by wheelchair-users, ambulant disabled passengers and able-bodied passengers (excluding escorts). Ir was originally intended that drivers would issue the appropriate form to all disabled users and by linking the returned questionnaires with other records the effects of multiple-use or regular travellers could be taken into account. In the event, drivers did not keep sufficiently accurate records for this to be practical and drivers, understandably, were unwilling repeatedly to ask regular users to complete the same questionnaire. However, with the aid of drivers' records and the responses to questions on frequency of use of the vehicle or whether a form had been completed before, a reasonable assessment of the number of individual respondents can be made.

Table 5.1 shows the number of passenger trips in each category, obtained from vehicle log-sheets, together with the number of returned questionnaires at each placement. The number of questionnaires in the group definitely known to include only one questionnaire per respondent is also shown.

The analysis presented here is based mainly upon the questionnaire returns; the interviews generally corroborate these. It is not clear cut whether it is more appropriate to concentrate analysis on the total number of questionnaires returned, thereby more accurately reflecting users' views on a per-trip basis, or to analyse just the first or only response, thereby reflecting users' views on a per-individual user basis. In practice little difference emerged between the results expressed in either form, implying that multiple users and single users hold similar views about the vehicles. The results presented here are based on total questionnaire returns, unless otherwise stated.

As can be seen from Table 5.1 there are limited results available in a number of categories, due mainly to the relatively short period over which data was available from Stoke and Edinburgh. There were also a limited number of passengers in some categories. The majority of the results presented relate, therefore, to an aggregated data set comprising returns from all four placements. Differences between the placements, where these can be detected, are discussed in the text.

TABLE 5.1 Number of questionnaires returned and interviews conducted at each placement

Category of passenger		Newcastle	Peterborough	Stoke	Edinburgh	Total
Wheelchair-users	No. of passenger trips	745	803		n/a	n/a
	Total no. of questionnaires returned	38	60	20	5	123
	No. of first or only questionnaires returned by each individual	22	37	20	4	83
	No. of interviews	11	8	-	-	19
Ambulant disabled passengers	No. of passenger trips	315	92		n/a	n/a
	Total no. of questionnaires returned	27	28	1	9	65
	No. of first or only questionnaires returned by each individual	16	10	1	9	36
	No. of interviews	10	1	-	-	11
Able-bodied passengers	No. of passenger trips	3	6505		n/a	n/a
	Total no. of questionnaires returned	2	127	9	-	138
	No. of first or only questionnaires returned by each individual	1	79	8	-	88
	No. of interviews	0	47	-	-	47

n/a - not available

In practice, around 1/3 of individual disabled users completed questionnaires, although at first sight Table 5.1 suggests that a very low response rate was obtained. This is explained by two main factors. First, the definition of passenger trip used here is a one-way journey and most journeys made by disabled passengers were two-way. Secondly, a high proportion of disabled passengers made multiple journeys in the CR6. Thus, for example, the 803 passenger trips made by wheelchair-users in Peterborough represents some 400 return journeys by approximately 150 individuals. Sixty returned questionnaires thus represents about a 40% sample of individual travellers.

The multiple use of the CR6's by disabled passengers was quite marked, as shown in Table 5.2. This corroborates the comments made in section 4.4, based on operators' records. It should also be noted that the results presented in Table 5.2 will tend to underestimate long-run multiple use, because the data cover a limited period, before steady-state conditions had been achieved.

TABLE 5.2 Frequency of use of CR6

Frequency of previous use of CR6	Wheelchair user No.	Wheelchair user %	Ambulant disabled No.	Ambulant disabled %	Able-bodied No.	Able-bodied %
Never	69	57	31	48	85	62
Once	20	16	9	14	20	14
2-5 times	20	16	18	27	25	18
6-10 times	4	3	4	6	4	3
More than 10 times	9	8	3	5	4	3
Total responses	122	100	65	100	138	100

Category of passenger

Source: questionnaire responses

5.2 Characteristics of passengers

As would be expected from national statistics, the disabled passengers were much older than the able-bodied and 2/3 of them were female. Twenty-two per cent of wheelchair-users were under 50 years of age, a very similar proportion to that found in wheelchair-using residents of North Tyneside (Hall and Silcock, 1984) and in Fenwick's (1977) national survey of DHSS wheelchair-users.

Few disabled passengers were employed, compared with 60% of able-bodied passengers.

In response to the question, "do you or your immediate family own a car", 50% of able-bodied users answered "yes", whereas only 42% of wheelchair-users and 26% of ambulant disabled passengers answered "yes".

Disabled passengers were asked whether they were in receipt of mobility allowance;* 60% of wheelchair-users but only 17% of ambulant disabled passengers reported that they were.

5.3 Characteristics of journeys

The reported journey purpose of the CR6 passengers is given in Table 5.3. As would be expected from the limited number of disabled people in employment, work journeys are few. Visiting friends and relatives is a common purpose for all categories of users with leisure activities also being a common activity. More than half of all trips in the CR6 were for one or other of these two purposes.

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* A tax-free allowance of £988 per year to disabled people to help cover additional costs of mobility.

TABLE 5.3 Journey purpose of respondents

Journey purpose	Category of passenger					
	Wheelchair user		Ambulant disabled		Able-bodied	
	No. of respondents	%	No. of respondents	%	No. of respondents	%
Work	1	1	-	-	24	18
Shopping	27	22	13	20	10	7
Education	2	2	1	2	2	2
Medical	16	13	13	20	7	5
Visit friends/relatives	27	22	15	23	40	29
Clubs/societies	15	12	9	14	14	10
Other leisure	20	16	8	12	24	18
Personal business	3	2	-	-	12	9
Other (including multiple purposes)	12	10	6	9	3	2
Total	123	100	65	100	136	100

Source: questionnaire surveys

TABLE 5.4 Reported cost of journeys in the CR6

(a) by category of passenger

Cost of journey to the passenger	Category of passenger					
	Wheelchair-user		Ambulant disabled		Able-bodied	
	No. of respondents	%	No. of Respondents	%	No. of respondents	%
Free	17	14	7	11	3	2
Less than £1	3	3	6	10	5	4
£1.01 - £2.50	57	47	38	61	97	72
More than £2.50	43	36	11	18	30	22
All journeys	120	100	62	100	135	100

(b) by Placement

Cost of journey to the passenger	Newcastle		Peterborough		Stoke		Edinburgh		All	
	No. of respondents	%	No. of respondents	%	No. of respondents	%	No. of respondents	%	No. of respondents	%
Free	20	31	7	3	-	-	-	-	27	[illegible]
Less than £1	6	9	7	3	1	3	-	-	14	[illegible]
£1.01 - £2.50	24	38	154	73	8	29	6	46	192	61
More than £2.50	14	22	44	21	19	68	7	54	84	[illegible]
All journeys	64	100	212	100	28	100	13	100	317	100

Source: questionnaire surveys

Passengers were asked to report how much the trip cost them. In some cases the journey is free to the user, or subsidised, because it is at the expense of an organisation which had made separate arrangements with the operator. Table 5.4 presents the reported costs.

The assessment of questionnaires does not permit any consideration of trip lengths. However, on costs alone it is clear that Newcastle users paid less on average than those in Peterborough. From limited data it seems that Stoke travellers paid more than either of these (despite the influence of Staffs. C.C. subsidy of 50% of the cost of a journey within Staffordshire involving a disabled passenger).

These results are consistent with the operators' records. The differences between placements appear to be greater than the differences between the 'ability' classifications of users, local factors appearing, therefore, to be more important than disability in determining the extent of journeys in the CR6.

5.4 Access and egress for disabled users

Ambulant disabled respondents in all four placements were asked about use of the ramp. Twenty per cent made use of it to gain access. Wheelchair-users were not asked whether they used the ramp during the first placement because it was assumed that all would require it. When it became apparent that some drivers were not using the ramp to load wheelchairs then questions on ramp use were included at the start of the second placements. Of the 24 wheelchair-users completing this aspect of the questionnaire, only 4 (17%) had not used the ramp.

Only 8 wheelchair-users (7%) and 28 ambulant disabled passengers (47%) claimed that they could have managed to get in and out of the vehicle without help. The person helping was generally the driver. Table 5.5 shows where help was essential, in the respondent's view (note that this is not necessarily the same as where help actually was provided).

TABLE 5.5 Where help was reported as essential by disabled passengers

	Category of passenger					
	Wheelchair user			Ambulant disabled		
	No. needing help	%	Sample size	No. needing help	%	sample size
nowhere	3	2	121	26	43	61
in getting up the ramp or into the vehicle	109	90	121	29	48	61
in locating the wheelchair or getting into the seat	93	77	121	9	15	61
in fitting the restraint	48	53	90	n/a	n/a	
in getting out	103	85	121	31	51	61

Source: questionnaire surveys

5.5 Comfort and safety

Passengers were asked to indicate, on a semantic scale, their views on the comfort and safety of the CR6. Very few passengers, of any category, felt uncomfortable or unsafe in the prototypes. Stoke users gave the CR6 rather lower comfort and safety ratings than those in Newcastle and Peterborough, but the general response was very favourable indeed.

5.6 Changes in mobility for disabled passengers

The accessible nature of the CR6 may well provide opportunities for travel which otherwise are denied. Disabled passengers were asked whether they could have made their current trip if this type of vehicle were not available. Forty-six out of 119 (39%) of wheelchair-users and 16 out of 64 (25%) of amulant disabled passengers replied that they could not.

The responses to the question "how much difference to your travel would there be if all taxis were like this?" showed 94% of wheelchair-users to think "easier" or "much easier", with a corresponding 73% for ambulant disabled passengers.

The alternative modes of travel stated by those passengers who said that they could have made their current journey if a CR6-like vehicle was not available are given in Table 5.6. As can be seen private car and other taxi predominate.

TABLE 5.6 Alternative modes of travel for disabled passengers were CR6 not to be available

Alternative mode if CR6 type taxi not available	Category of passenger			
	Wheelchair-user		Ambulant disabled	
	No. of mentions	%	No. of mentions	%
walking or in wheelchair (alone)	4	4	2	3
walking or in wheelchair (with helper)	7	7	2	3
private car	25	26	10	14
other type of taxi	30	32	35	51
bus, train or metro	1	1	6	9
Social Service transport, ambulance or voluntary group vehicle	27	29	14	20
other	1	1	-	-
Total no. of times mode mentioned	95	100	69	100
Total respondents	79		54	

Source: questionnaire surveys

5.7 Attitudes of able-bodied users

Able-bodied users were asked three supplementary questions to establish their frequency of taxi travel and attitudes to the prospect of all taxis being CR6's, possibly with higher fares.

About half of the able-bodied users travelled by taxi once a week or more. Two-thirds (91 out of 135) would not object at all were all taxis to be like the CR6 and only 11% would object moderately or very much. However, most would be unwilling to pay higher fares because of the special nature of the taxi. Only 13% (18 out of 135) had no objection to paying a "somewhat higher fare" and 51% (69 out of 135) had a strong objection. Those who travelled more often by taxi were much less likely to accept a higher cost with equanimity.

5.8 Conclusions on passengers' views

Disabled users of the CR6's conform broadly to the disabled population as a whole, in terms of their age and sex.

Even with a vehicle designed to accommodate wheelchairs, 13% of those surveyed transferred from their chair to the passenger seat. Passengers preferred to travel facing forwards, with backwards facing being preferred to a sideways orietation.

The great majority of wheelchair-users and about half of the ambulant disabled passengers needed assistance at some stage when using the taxi. The most common place where help was needed was in entering or leaving the vehicle.

Passengers were very favourably impressed with the comfort and perceived safety of the vehicle. Disabled passengers, in general, showed very little inclination to criticise the CR6 in any way.

Over 1/3 of wheelchair-users and 1/4 of ambulant disabled users reported that they could not have made their current trip if the CR6 had not been available. The great majority of disabled passengers thought that the CR6 had made their travel easier.

The able-bodied users who were surveyed were generally well-inclined towards the CR6 concept provided it did not lead to increased taxi fares for the general public.

6. VALUE OF THE TRIALS

6.1 Introduction

The value of the trials must be judged against their immediate aims; first to evaluate the design of the CR6 for use by disabled people and secondly, to examine the operational performance of the prototype vehicles. These aims stemmed from Carbodies' and DTp's wish to ensure that the final design package was as suited as realistically possible to the needs of disabled people and that prospective roles for an accessible small vehicle be examined.

6.2 Influence on the design

When the trials began in 1982, it was intended that the production model would be in service early in 1984. Thus, for the results of the evaluation to have any influence on the final design concept, early feedback was needed.

It became clear early in the trials that wheelchair-users would benefit from a wider doorway and more space within the passenger compartment to facilitate turning the chair into the rearward facing position. This was corroborated by simulation tests on a mock-up of the passenger compartment. In the absence of an adequate data base describing the size of wheelchairs and their occupants who were prospective taxi users it was difficult to provide objective advice on by how much to increase the relevant dimensions.

Nevertheless, production tools were to be ordered and judgements had to be made, based on the best available evidence at the time. That evidence consisted of some controlled experiments with particular groups of disabled people, limited measurements of wheelchairs at a number of day centres, rig-tests and the experience with the two prototypes to date. This suggested that a 100 to 150mm increase in the interior length of the passenger compartment, with a similar increase in door width, would be very beneficial.

A change in door height and interior height were considered at the same time. Much less evidence was then available about heights and although it was recognised that an increase would be beneficial, the scale of change needed to produce a noticeable improvement was unknown. This, combined with financial constraints, meant that only the length and door width were increased, by about 100mm.

It should be noted here that the two prototypes undergoing trials have remained unchanged and that the number of prospective passengers who could not gain access during the trials has been very few. The benefits from the increased length of the production model will be seen mainly in easier manoeuvrability within the vehicle and less damage to the vehicle's trim.

The limited extent and unreliable nature of the data referred to above stimulated the North Tyneside Wheelchair Size Survey, referred to previously. The results of that survey support the decisions which were made and provide a useful data set for others working in the field.

The change in basic dimensions referred to above is the most substantial influence which the trials have had on the production vehicle, but there are a number of other no less important, if less costly, improvements which have followed from the results of the trials.

It can fairly be stated, therefore, that the trials have had a major impact on the final design - in terms of the passenger compartment and access by disabled people.

6.3 Operational aspects

The data collected during the four placements enable a number of conclusions to be drawn about the scope for CR6-like vehicles in a variety of operating environments. These are discussed in section 7.

Reactions from many users are also of value in reviewing the roles of CR6, other than its basic one of a taxi-cab.

Caution is needed, however, against using the results of the trials for market assessment. The presence of just one CR6 in each of the four operating areas, and deliberate emphasis in some cases on the transport of disabled passengers, means that the operating statistics are far from representative of the conditions which would prevail were many or all of the taxis in an area to be accessible. The known short-term nature of the placements may also have had an influence on use.

6.4 Conclusions on the value of the trials

Viewed overall, the trials have made valuable contributions to the evolution of the production model of CR6 and have yielded a variety of useful data regarding the use of small vehicles by disabled people. In summary:

(i) they have contributed towards improving the capability of the production model to meet the needs of disabled people;

(ii) they have provided firsthand experience in the use of small vehicles by disabled people in a variety of operating environments;

(iii) they have yielded a range of statistics on the use of a small, accessible vehicle by disabled people; and

(iv) they have stimulated other surveys which will enhance the body of knowledge in the subject.

7. DISCUSSION AND GENERAL CONCLUSIONS

The trials have seen the two prototypes operated in a variety of ways in the four placements. As described in section 4 these have met with mixed results, in terms of demands and by implication financial viability. Generally, the prototypes functioned very successfully as taxis or when providing private hire services. They had much less success when tried on a stage-carriage service in Stoke and their limited capacity resulted in few contract hires from organisations such as DHSS.

The predominant use of the vehicles by disabled people was for private hire, generally arranged by individuals. This accords with its basic role as a taxi and that the most intensive use during the trials occurred in Peterborough, where it was operated by a taxi company. The evidence from the other placements reinforces this, however, and suggests that there is limited scope for using CR6 or similar small vehicles for collective transport.

Section 5 presents a picture of widespread approval from amongst those disabled passengers who used the prototypes; many of them more than once. For some, the CR6 had provided opportunities to travel which previously just did not exist.

Viewing the vehicle as a conventional taxi, its accessible nature does not appear to have detracted from its basic role, although this is very difficult to judge from the operation of a single vehicle in an area. Able-bodied users who were surveyed gave widespread support to the concept provided it did not lead to increases in taxi fares for the general public.

Almost all trips in the vehicles by disabled people were pre-booked. Until accessible taxis are much more widely available it is not possible to judge whether this was because only one vehicle was available or whether disabled people are more likely to seek the additional peace of mind gained from having made a firm booking for a taxi. The impressions gleaned from the home interviews forming part of the North Tyneside Wheelchair Size Survey suggest the latter hypothesis to be more likely.

The brave decision of Carbodies to allow public scrutiny and very early field testing of vehicles which were not yet at the engineering prototype stage has led to the collection of much useful data. It also allowed informed judgements to be made on design decisions which will have material benefits for the production model.

The conduct of trials and the other surveys and testing which surrounded them have provided a base to develop guidelines for the design of small vehicles which are intended to be accessible to disabled people. Such guidelines can be used by designers of vehicles which are intended from the outset to be accessible, or by those modifying production vehicles. They are also of interest to licensing authorities when considering changes to the permitted specification of taxis.

Overall, the trials have established the success of the CR6 - in terms of its ability to transport disabled people - and have produced valuable information for those involved with their transport problems.

8. ACKNOWLEDGEMENTS

The work reported here was carried out under contract for the Vehicle Engineering Division of the Vehicles and Systems Assessment Department of the Transport and Road Research Laboratory. The contribution of Mr. K. Holmes of that division is gratefully acknowledged.

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An Ergonomic Evaluation of SCAT,
a Motorized Modular Platform Vehicle
for Transfer of Elderly and Disabled Persons

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ABSTRACT

This paper describes and presents results of an ergonomic evaluation of SCAT (Small Carrier for Alternate Transport), a prototype modular motorized platform vehicle developed by Transportation Development Centre for use in transportation terminals and other complexes where long distances create transfer problems for young, elderly, and disabled persons. Designed by U. Rutenberg, the system consists of small compact light-weight platforms, one of which includes a motor driven by two 12v batteries. Operation is from a standing position, facing either toward or away from passengers. Curvature at the ends of the platforms and a crosswise linkage system keeps the turning radius short. Each platform has a ramp for wheelchair accessibility, a fold-up seat with armrests, and a handrail allowing a single unit to be pushed if desired. The evaluation covered a comprehensive set of test scenarios at Dorval airport in Quebec, Canada. Results indicated that, after some minor modifications to the prototype, the Mark II version of SCAT will contribute to a decrease in physical load of airline attendants presently assigned to transfer duties and an increase in efficiency of the passenger-handling system, while providing disabled and elderly passengers with comfortable, psychologically acceptable transfer service.

INTRODUCTION

A notable problem in transferring disabled and semi-ambulatory passengers from one area of a large transportation terminal to another - say, from the check - in counter to the bridge - is that one attendant must be assigned to escort each wheelchair passenger or, at most, one very small group of passengers. This arrangement not only puts a strain on available personnel resources, but also results in physical stress to those performing this task several times a day. Sometimes a motorized vehicle is available so that larger numbers can be handled at one time. However no such existing vehicle is directly accessible to a wheelchair occupant who must, accordingly, transfer from the wheelchair into the vehicle and back again at the within-terminal destination, and perhaps perform an additional transfer at this point to another chair - to either a narrow-aisle version to get to his or her seat, or the passenger's own chair which may be late coming up from baggage. SCAT (Small Carrier for Alternate Transport), designed by U. Rutenberg, M. Barber, and L. Goldik of Rutenberg Design Inc., was conceived (see Rutenberg & Barber, 1982) and developed by Transport Canada's Transportation Development Centre in recognition of this implied gap in transportation technology for the elderly and handicapped.

Ergonomic input through conceptual, mockup, and prototype development stages of SCAT contributed to an evolutionary design process the result of which is a device very much different in character from the one originally conceived. The field tests of the prototype are regarded as a large and important complement to this input, designed as they were to provide real-life information which would pinpoint any remaining system features needing modification. Most purely mechanical properties had been examined in detail in the workshop: thus the field tests were indeed largely ergonomic in nature, focusing on (a) operator handling of both vehicle passengers, (b) passenger reaction, and (c) performance of the vehicle in terms of procedures in a transportation terminal. This paper describes and reports results of these tests.

System Features

SCAT is a modular lightweight platform vehicle consisting of one 1.75- x .84-m motorized platform and one or more 1.22- x .84-m non-motorized platforms which may be linked together as needed. Linkage is effected by tie rods mounted cross-wise on the underside of each platform. As the ends of each platform are curved (radius - 1.5 m), two linked platforms rotate against each other in opposite directions in a turning manoeuver, so that the turning radius with three linked units is only 2.45 m. Figures 1a and 1b provide, respectively, an overall view of the system, and an illustration of the turning mechanism.

Figure 1 about here

Each platform is equipped with two fixed 10.2-cm castors on the rear: two front-mounted swivel castors complete the roll function for the non-motorized platform; on the motorized platform, one front swivel castor is mounted opposite the drive wheel. The 1/2 HP motor is driven by two 12v gel cell batteries; a gear box mounted directly on the drive wheel allows progressive speeds up to 5 kph; a built- in brake operates when the motor is stopped. The motor is positioned off centre to maximize space for manoeuvering a wheelchair. Operation, by means of a tiller lined up with the driver wheel and having a trigger at the end for gradual control of speed, is effected from a standing position which enables the driver to see over the heads of individuals walking in the passageway. Two hip-height metal driver perches offer support and/or orientation stimulation if either is needed. In particular, the driver can use the left hand on the perch in front to stablilize the body when negotiating curves. Figure 2 gives a close-up of the tiller; the driver perch can be seen in Figure 1 above.

Figure 2 about here

The grey vinyl-covered 1.9-cm plywood platforms are mounted on welded rectangular steel tubing frames. A bumper of red vinyl tubing 1.9-cm in diameter encircling a platform protects it against scratches. Each platform has a push rail, a fold-up seat with armrests, and a .76- x .42-m port-side ramp which folds up after use to act as a guard; all are made of steel tubing and and perforated sheet metal spray-painted a copen blue. The low 14-cm floor height of the platforms was designed to permit easy access by elderly or semi-ambulatory passengers, and to keep the slope of the ramp a small 1:4 for accessibility by wheelchairs. Figures 3a and 3b show the ramp being, respectively lowered and raised; the seat can be seen in the fold-up position in these illustrations.

Figure 3 about here

METHOD

Subjects

Four volunteer passengers were carefully selected to test out certain features of SCAT. In addition two actual passengers agreed to take a test ride. Four volunteer operators were obtained through the auspices of Air Canada. Subject descriptions and their relationships to test functions are set out in Table 1.

Table 1 about here

Test Site

Time and money constraints dictated that only one site be selected. Dorval air terminal was a logical choice because of its proximity to the development site; however, apart from this consideration, the size and layout of Dorval are such that a comprehensive series of test scenarios could be devised.

Procedures

Each operator subject was shown how to (a) unlock, fold down, fold up, and lock both the ramp and the seat, (b) manoeuver a wheelchair onto and off both the motorized and non-motorized platforms, and (c) start, stop, and turn the vehicle. Each passenger subject was briefed on the nature and function of SCAT and assured of its safety, before undertaking activities in accordance with the test functions outlined in Table 1.

Operations were given an opportunity to carry out some experimental manoeuvering of the vehicle and to practise loading and unloading a wheelchair before actual trial runs. Subsequently they guided SCAT from the ticket area through a narrow doorway (5.1 cm clearance) to Security, into the waiting lounge and on to the farthest gate about 200 m distant, up and down two different loading bridges (with slopes of approximately 1:12 and 1:18 respectively), to Customs via elevator, to the baggage carousels and, finally, to the taxi area outside. Extensive filming was done of these tests. All subjects, operators and passengers, were encouraged to be critical; their free-flowing comments were taped, as were responses to specific probes regarding system features.

Airlines officials responsible for passenger and materials logistics were given a demonstration of SCAT and questioned regarding its perceived utility for their purposes. These interviews were neither filmed nor taped.

RESULTS

Operator Tasks

Some eye-hand coordination difficulty was experienced by subject operators in attempting to fold and unfold the seat because manipulation of the positioning plates on the vertical seat support structure requires that both hands be used at once. The remedial measure will involve a connecting rod with a handle so that both plates can be moved simultaneously.

Observations indicated that males tended to push the wheelchair forward up the ramp, while females tended to pull it up backward. The latter mode of accessing the platform is less stressful than the former since the small front revolving wheels of the chair are less able to overcome resistance on meeting the metal tubing lip of the ramp than are the large rear wheels. Moreover, the backward pull-on movement allows the attendant to tilt the chair so that the occupant's weight is directly over the wheel axles, thus reducing the physical load. Once the chair is on the platform, the attendant can easily manoeuver it into position by stepping backwards onto the floor and working from behind the chair. Unloading is done by rotating the chair into ramp-facing position, tilting it backwards, and moving forward down the ramp. Relevant manoeuvers are shown in Figure 4.

Figure 4 about here

No complaints were received regarding the nature of the driver perch although, clearly, its fixed position makes it impossible for operators of different heights to use it against the same part of the body. Subject reports indicate that it serves its intended purpose, namely, to stabilize or orient the driver rather than to take the driver's weight. Figures 5a and 5b show, respectively, a male and a female operator using the perch comfortably for balance.

Figure 5 about here

Instructions regarding operation of the vehicle were readily understood. However certain control difficulties were observed. For example, some operators tended to pull the trigger at the end of the tiller too quickly at first, this causing the heavily treaded drive wheel to spin; subsequent action of pulling the trigger even harder, while intended as corrective, only increased the wheel-spinning. Control responses such as these were particularly evident after a sharp turn at too high a speed had stalled the vehicle because of drive wheel spin.

This behaviour does not appear to be attributable to either low control-response ratio, which would result in an overshoot response (see McCormick & Sanders, 1982), or initial resistance in the trigger movement, a condition which might induce the operator to apply excess pressure. Rather it seems likely that, in this type of vehicle, the operator does not have the auditory and kinaesthetic feedback familiar to the automobile driver, which indicate that the drive wheel is spinning; thus, believing that the vehicle is simply not responding to the control movement, the operator tends to pull the trigger harder to obtain the desired vehicle response. When advised to press the trigger gently, operators were able to avoid wheel spinning. Nevertheless, it is necessary to ensure maximum compatibility between, on the one hand, perception of vehicle velocity obtained (Bartley, 1969) through kinaesthetic, visual, and vestibular information and, on the other, proprioceptive feedback associated with pressure on the trigger and its displacement. Accordingly, the trigger will be replaced with a thumb-operated sliding switch on the top of the tiller so that visual feedback regarding amount of displacement of the control can be added to that obtained through proprioception.

Some initial difficulty in perceiving the relationship between the movement of the tiller and movement of the vehicle during turning manoeuvers was also evident. For example, drivers tended to operate the tiller too early in order to effect the turn required after entering the door to Security. Because of its very short turning radius, the correct strategy with SCAT is to move right to the door and then to run sharply at low speed. A small amount of practice was sufficient to overcome all control problems with the observed sample, a fact suggesting that training in control of the vehicle, although necessary, would not be time-consuming.

The adjustability of the tiller, designed this way to allow the driver to face either forwards or backwards, proved serendipitously advantageious in another respect, namely, in that it could be adjusted to the length of the arm of the driver regardless of the direction of facing. This feature can be considered important in light of the fact that operators would be drawn from both male and female populations and, therefore, would vary widely in body dimensions. In Figure 6, the operator has the tiller within comfortable reach.

Figure 6 about here

In general, problems experienced with SCAT by subject operators were few and readily soluble, and a common comment by these volunteers was to the effect that such a vehicle would provide an effective answer to difficulties they now encounter in transferring special needs passengers. This was particularly true of the females who, although they are on the average smaller in stature (McCormick & Sanders, 1982, p. 315) and overall strength (Hosler & Morrow, 1982) than are males, are nevertheless usually assigned the task of escorting wheelchair passengers to and from the bridge. The physical load incurred in these cases is particularly heavy on the ramps, and it would not be surprising to see increases in the incidence of back, arm, and shoulder strain among these employees; the real danger of course, as Tichauer, 1978 points out, is that small effects may be ignored on a day-to-day basis only to surface cumulatively as a seriously debilitating problem some time in the future.

Passenger Considerations

Semi-ambulatory volunteer passengers found it extremely easy to get onto SCAT platforms, not just because of the low floor height, but also because of the tubular driver perch and seat parts which they readily used for stabilization. The seats were found to be comfortable despite their metal construction, likely because their perforated nature renders them somewhat flexible. It was noted, though, that the mother and child fully occupied one seat, and that two people of normal size would likely feel cramped if it were necessary for them to sit together for a long period. However SCAT was not conceived as a long-haul vehicle, but rather as one which would overcome distances difficult for the non- and semi-ambulatory; hence some compromise in seating comfort is necessary in order to keep the vehicle narrow enough to get through doors and into elevators. In Figure 7, a semi-ambulatory subject makes use of the metal seat arm to help him get to his feet. Figure 8 illustrates the nature of seat capacity.

Figure 7 about here

A fully ambulatory individual could push a non- or semi-ambulatory passenger, if this mode were acceptable to the airlines. The volunteer for this test, although elderly, found SCAT easy to manoeuver in this way and was able to maintain an erect posture while doing so.

Figure 8 about here

During the backward pull-on access mode, wheelchair subjects reported experiencing a feeling that the attendant had the chair well under control. Such confidence is well founded in fact since, as pointed out earlier, control is indeed greatest in this mode.

All volunteers spontaneously mentioned that a vehicle like SCAT would facilitate travel for them. But perhaps the greatest indication of this fact was manifested by the two actual passengers who, in wheelchairs because of temporary ambulation difficulties, had "hitched" a ride during the testing period. Since it is possible for both ambulatory and wheelchair passengers to access SCAT right at the end of the bridge, it is clear that these individuals could have avoided use of a wheelchair altogether had such a vehicle been in service at the time. Their reaction was extremely favourable.

However some uneasiness was witnessed on the ramps where it became clear that additional restraint of the wheelchair is necessary. To this end, the Mark II version of SCAT will have a restraint in the form of a length of 60 cm long sailcord, 1 cm in diameter, attached with a cleat to the centre rear of each platform, and fashioned with a hook at the end for the rear crossbar of the wheelchair frame. In addition, of course, wheelchair passengers can avail themselves of the 5-cm nylon webbing lap belt, actually meant for seat passengers, by simply passing it under the armrests of the chair.

SCAT and Passenger-Handling Procedures

SCAT was able to negotiate the two bridge ramps attempted, both ascending and descending; hence, with this vehicle, wheelchair and semi-ambulatory passengers could be brought right to or picked up at the door of the plane. However aluminum joints on the flooring on these ramps did present some difficulty, the vehicle tending to stop with the drive wheel spinning. The problem was particularly acute when, as was frequently the case, the floor levels at the joints were slightly different. Some alleviation can be brought about by replacing the castors with pneumatic tires; however, inasmuch as these joints constitute a hazard for ambulating passengers and staff, the better solution would seem to be found in alteration of the flooring. On the flat runs, the vehicle moves at about the same speed as the pedestrian traffic in a fluid and unobtrusive manner, even when three units are linked together. In addition, it has an aesthetic appearance which, unlike existing motorized units used in terminals, offsets any clinical connotation which might be associated with its mission. In Figure 9, the operator guides SCAT through a narrow doorway.

Figure 9 about here

It was also possible to use the elevator at Dorval with SCAT, although this procedure involved disconnecting linked units and bringing each up or down separately. The push rail on non-motorized units is of course essential for this operation. The availability of the push mode also makes it possible to ease passenger handling by having a fully ambulatory passenger (instead of a staff member) use the vehicle to get a semi- or non-ambulatory travel companion to and from destinations within the terminals. Since baggage push carts are already in widespread use in terminals, an extension of the concept to include disabled and elderly passengers would seem to be a logical step.

While, as mentioned earlier, operator subjects were enthusiastic regarding the use of a vehicle like SCAT at the terminal, staff members responsible for passenger handling procedures were more reserved in their appraisals despite what is considered to be a successful demonstration of its utility. One comment was to the effect that breaking up a double- or triple-unit trip into separate units when level changes occur would be a nuisance. However, inasmuch as procedures now entail transfer of passengers in separate units, and as SCAT would overcome the greater part of the burden of such a system, the objection does not appear to have great thrust. On the whole, reactions to SCAT by the officials interviewed suggested a cautiousness of the kind frequently exhibited when new technology threatens to disrupt the status quo.

CONCLUSIONS

SCAT is a vehicle concept designed to facilitate transfer of disabled and semi-ambulatory individuals in transportation terminals. The field tests of the prototype, described above, revealed the need for modification of certain design features in order to render the system ergonomically sound. However these modifications, which will be implemented in the Mark II version, are very minor in nature. In general, the tests indicate that SCAT would decrease physical load of those assigned the task of escorting special needs passengers to and from the bridge, provide service to such passengers in a way that is comfortable and psychologically pleasing to them, and reduce demands on carriers' personnel resources. Although the evaluation was carried out in an airlines terminal, its performance there and its modular versatile design suggest that SCAT will be useful in any large complex where long distances creat problems in the transfer of not only young, elderly, and disabled persons, but also of goods and materials.

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Table 1

Subject Characteristics and Test Functions

Subject	Description	Test Function
Operators		
1	Air Canada attendant - male)	- manipulation of controls - control of vehicle) - handling of vehicle on and off the platform
2	")	- mental and physical load - male/female differences
3	Air Canada attendant - female - small in stature))	
4	Air Canada attendant - female - medium in stature))	
Passengers		
1	elderly male - volunteer wheelchair dependent upper body strength	- wheelchair accessibility and manoeuverability - sense of comfort, conspicuity, safety
2	elderly male with wife volunteer - using one crutch - walking distance less than 10 m	- accessibility by semi-ambulatory - seat comfort, sense of safety - push operation
3	male in 70s - actual passenger - using wheelchair temporarily to overcome distance to gate	- as for Subject 1 - check on social desirability effects in Subject 1's responses
4	as for Subject 3	- as for Subject 3

ACKNOWLEDGMENTS

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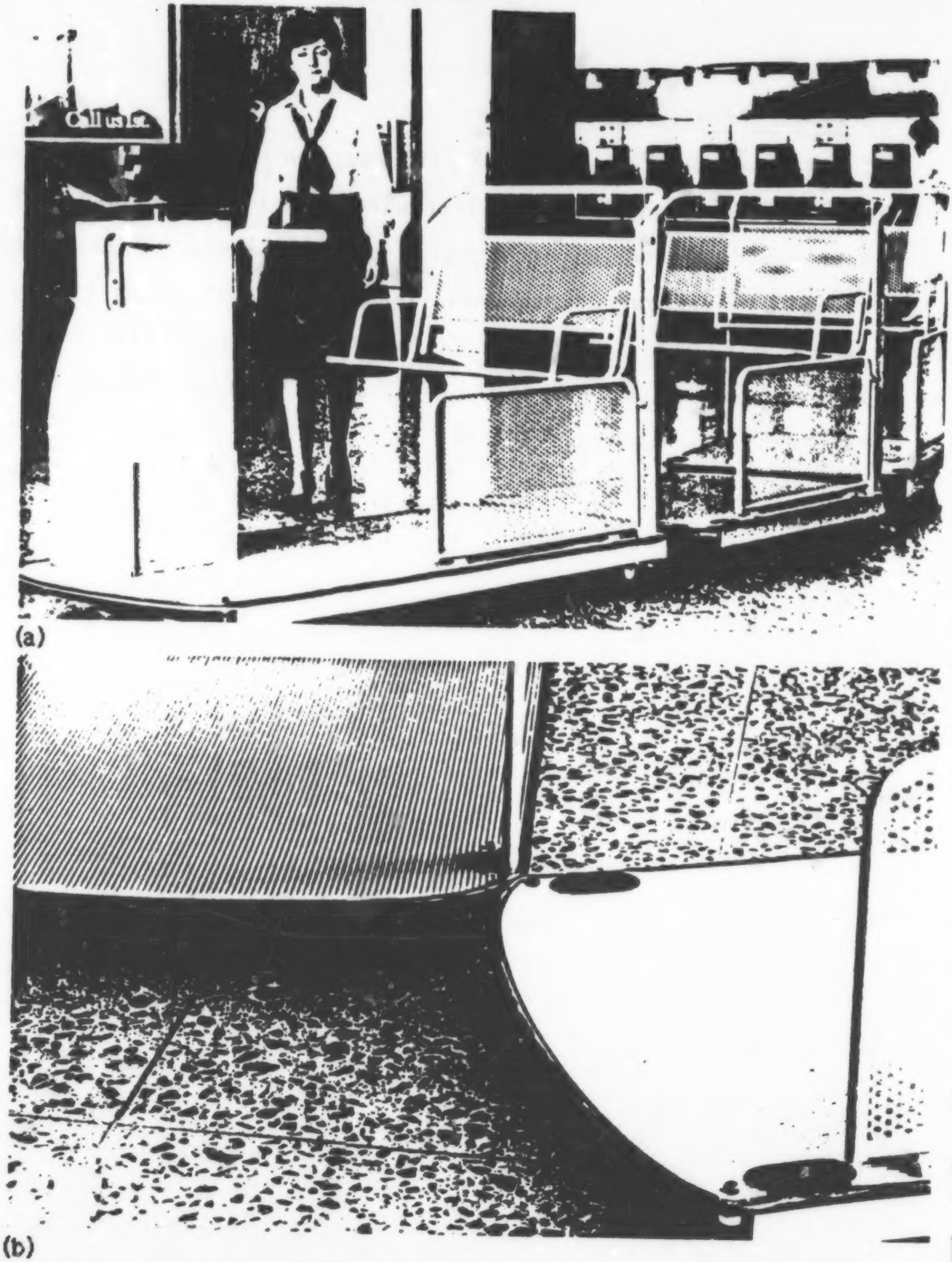

Figure 1. A general view of SCAT (a) with the the motorized and two non-motorized platforms linked together, and a closeup (b) of two platforms during a turn manoeuver.

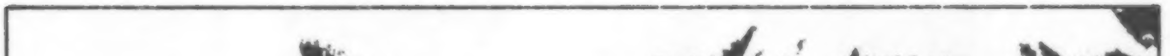

Figure 2. The steering tiller, with the index finger on the speed control trigger.

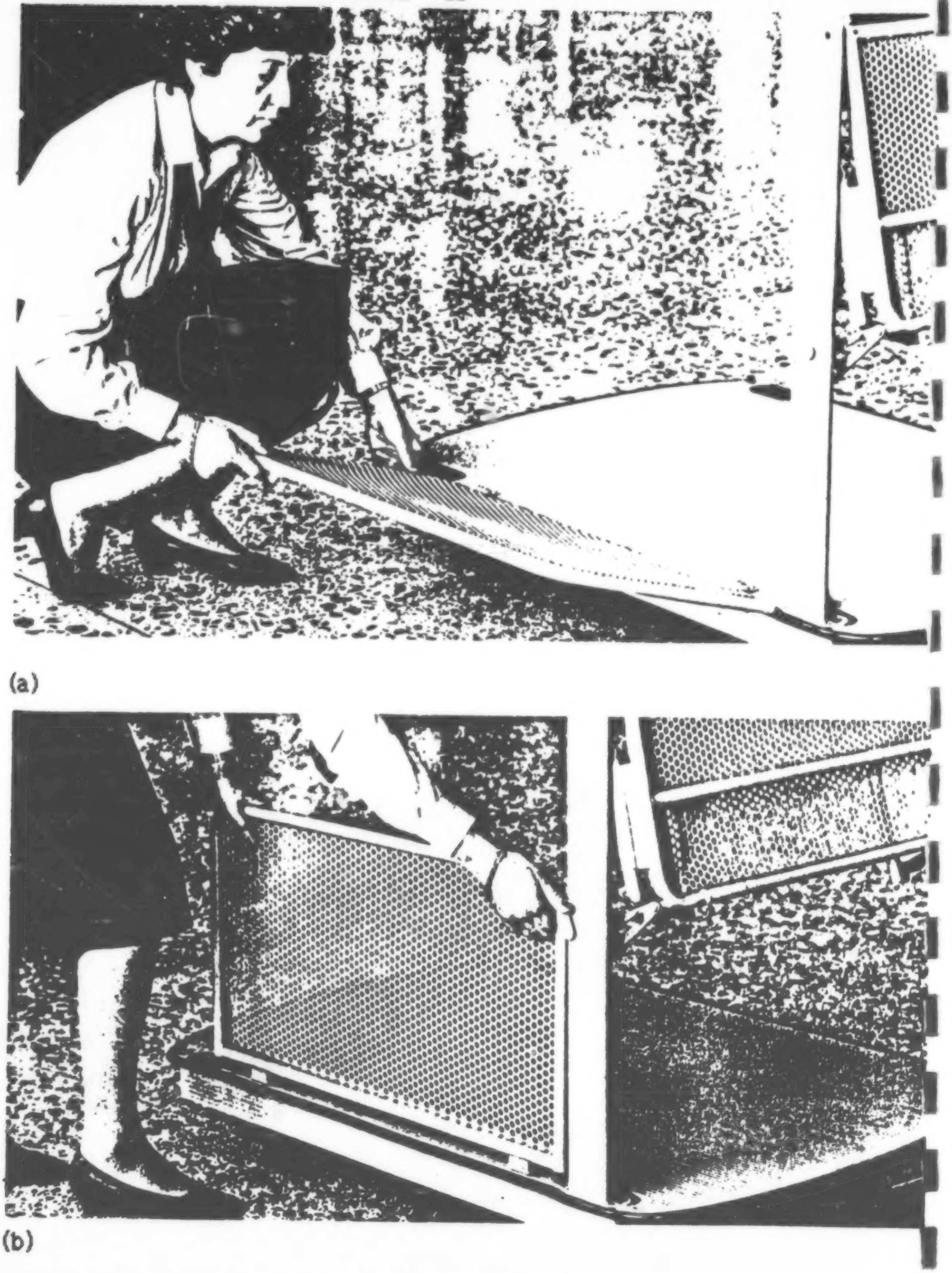

Figure 3. An operator obeys the knee-bending rule to relieve lumbar stress while lowering the ramp (a); in (b) she bends over to lock it in place. The seat is in the foldup position in these illustrations.

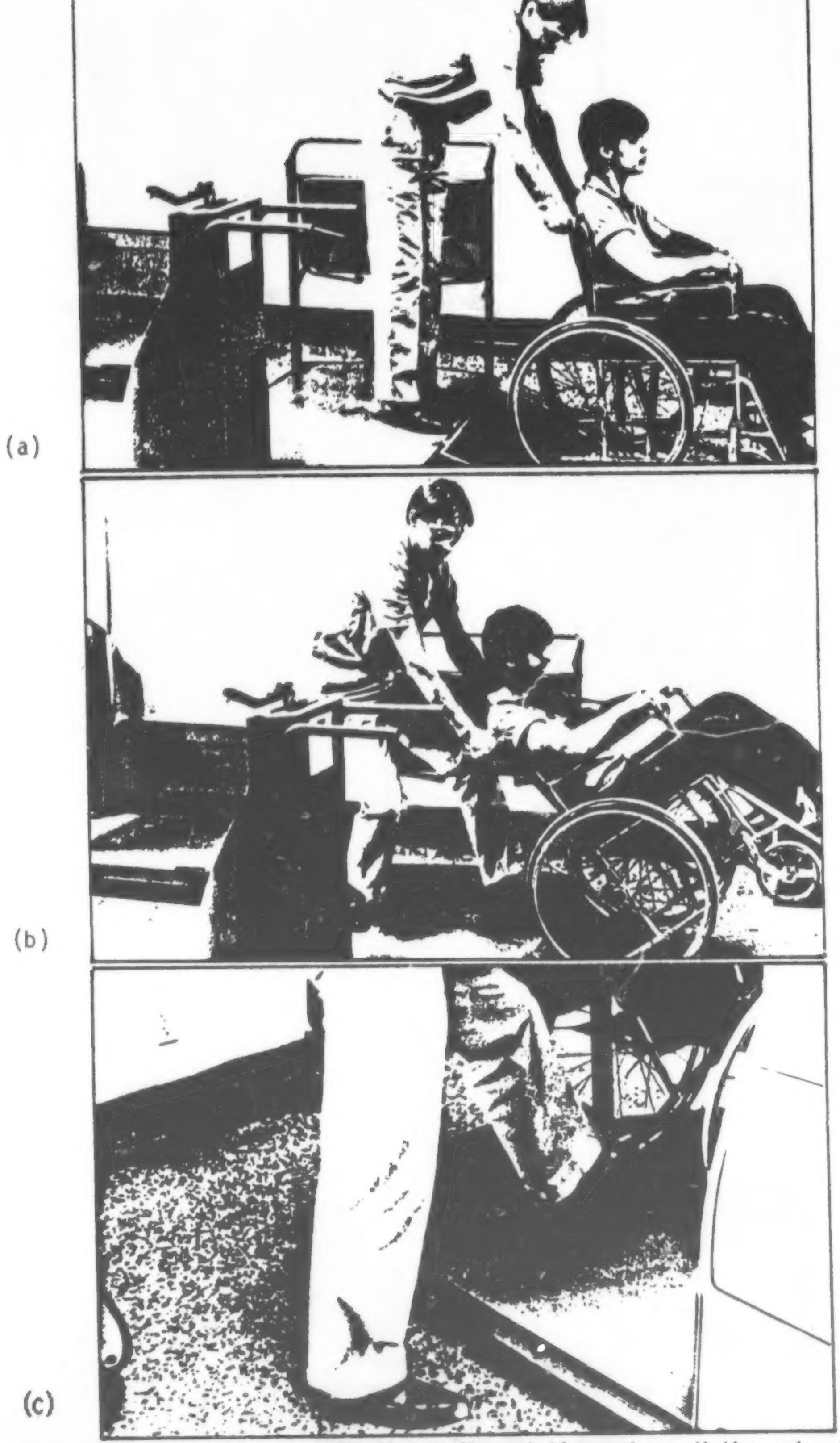

Figure 4. The operator stands on the platform to pull the wheelchair on backwards (a); to minimize load, the wheelchair is tilted so that the occupant's weight is over the wheel axles (b); the operator steps off the platform to rotate the chair into the forward-facing position. (c)

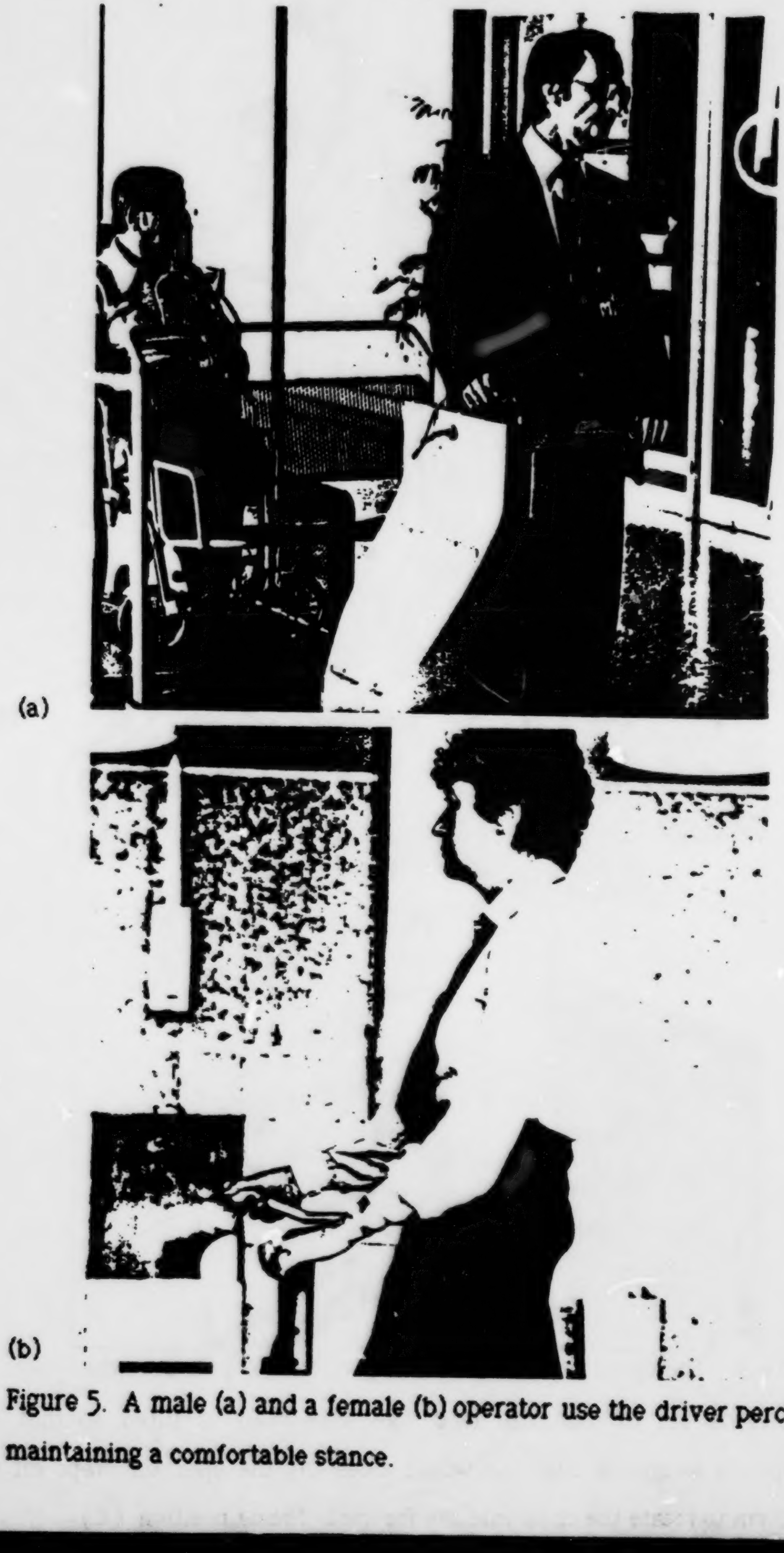

Figure 5. A male (a) and a female (b) operator use the driver perch while maintaining a comfortable stance.

Figure 6. The operator has adjusted the tiller to comfortable arm length.

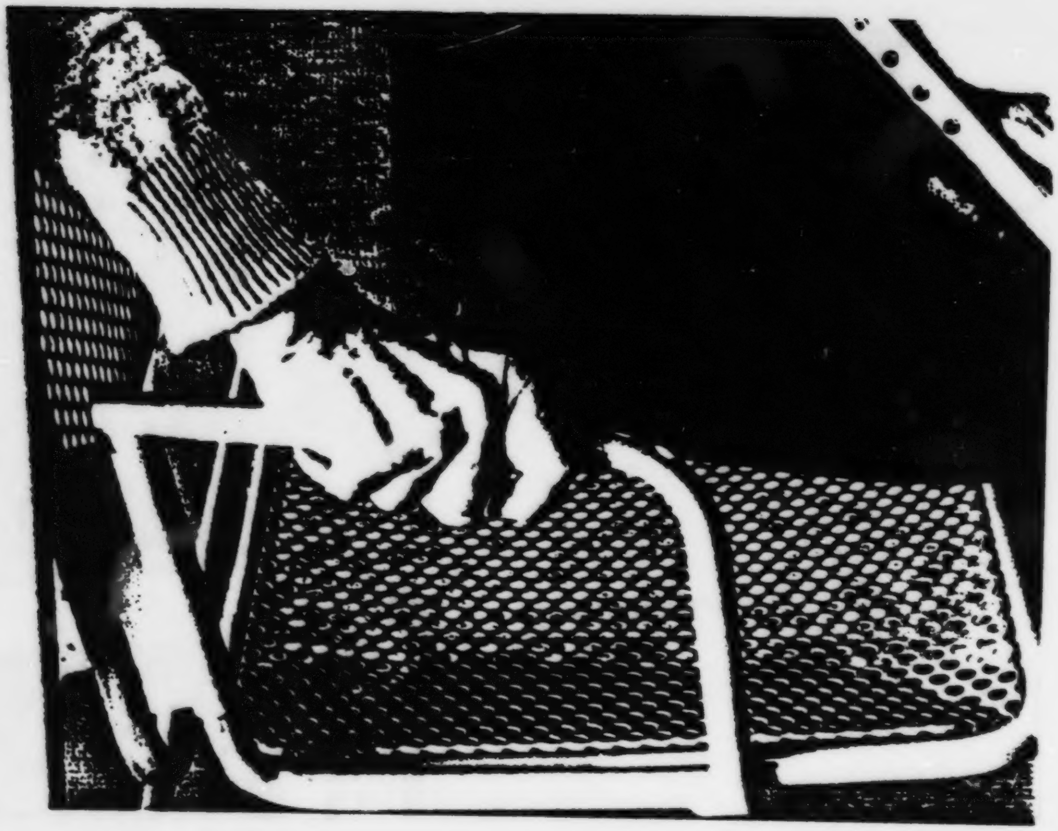

Figure 7. A semi-ambulatory subject supports himself with the metal seat armrest to get to an erect position.

Figure 6. The operator has adjusted the tiller to comfortable arm length.

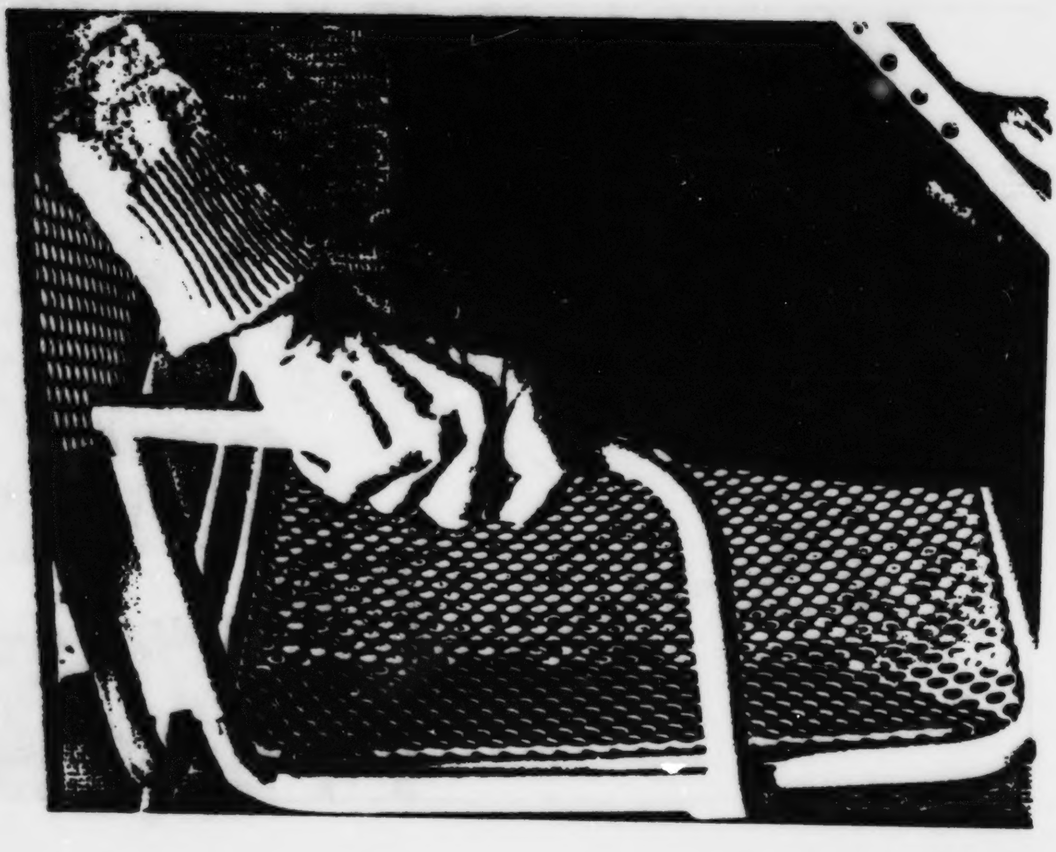

Figure 7. A semi-ambulatory subject supports himself with the metal seat armrest to get to an erect position.

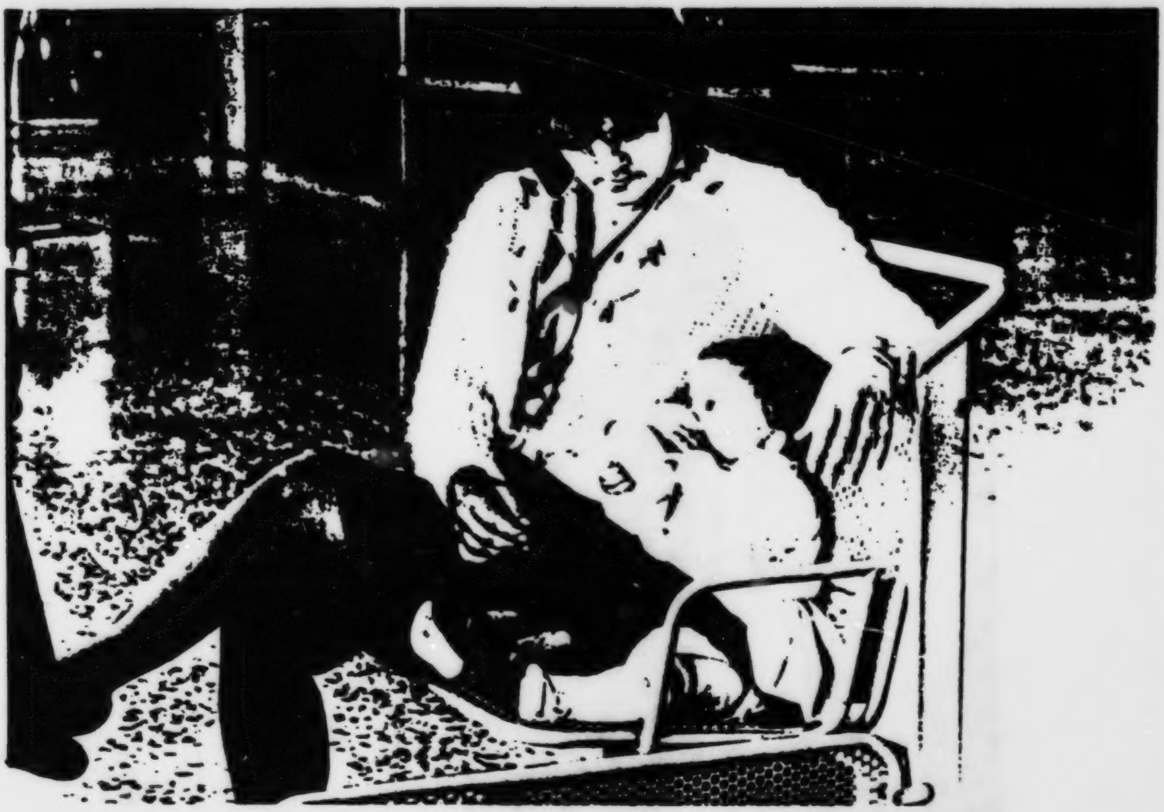

Figure 8. The female subject and her baby almost fully occupy the space available in a SCAT seat. The vehicle is necessarily narrow in order to get through doorways often found in terminals.

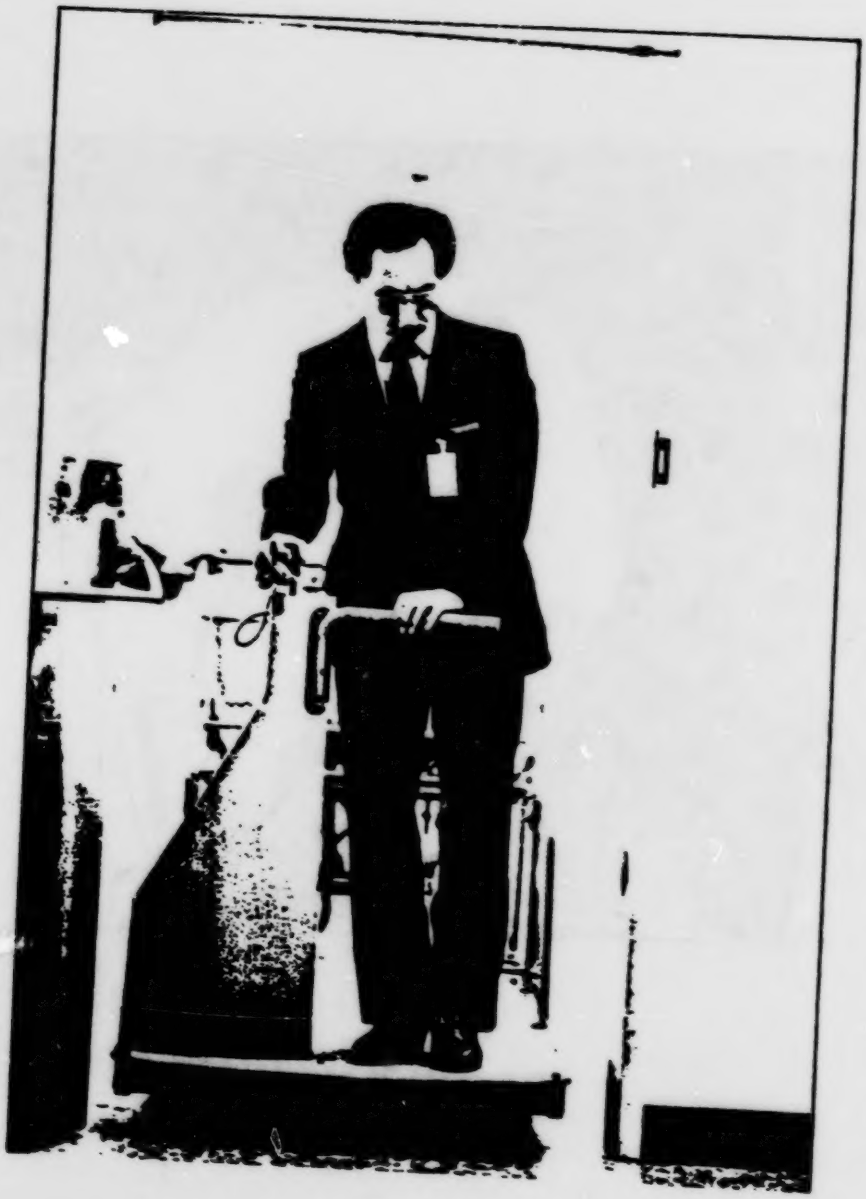

Figure 9. An operator has no difficulty guiding SCAT through this narrow doorway.

DEVELOPING AND IMPLEMENTING FUNCTIONAL ELIGIBILITY CRITERIA FOR USERS OF SPECIALIZED TRANSPORTATION SERVICES

Judith G. Hollander and Robert M. Works

I. INTRODUCTION

It is generally required that users of specialized transportation services for the disabled register prior to receiving such service. The purpose of registration, or certification, procedures is to ensure that only persons who need specialized transportation service will receive it. The determination of who "needs" these services, however, varies widely among specialized transportation sytems.

Screening potential users becomes especially important in times of limited resources. Because of the demand-responsive nature of these services and the special equipment involved, subsidy levels per trip for specialized transportation are usually high when compared with those for regular route transit service. It is therefore crucial that available resources be used to provide transportation to those who most need it and cannot rely on alternative modes because of their mobility limitations.

This paper describes a certification model developed for the Minneapolis-St. Paul metropolitan area in Minnesota. This model represents a systematic approach to the establishment of eligibility criteria. It advances a concept of certification on the basis of functional limitations as they relate to the use of transit, rather than on disability types, as a means of targeting service to those needing it. The paper also describes how this concept has been applied in practice. The criteria to assess physical and mental functional limitations are presented and reviewed.

This paper begins with a summary of some of the certification procedures used presently in some U. S. cities and an outline of some of the existing problems and shortfalls with these procedures. The essential issues in the development of eligibility criteria are then discussed, followed by a presentation of the proposed model and an explanation of its rationale. The process used in the model's development and some unsolved issues are reviewed. Finally, the recent impacts of this model are described focusing on various strengths and weaknesses presently observed by key participants in the system.

II. CERTIFICATION SYSTEMS

A. The Former Metro Mobility Certification Procedure

Public transportation for handicapped persons unable to use regular route bus service in the Minneapolis-St. Paul metropolitan area is provided by a demand-responsive service, known as Metro Mobility. Metro Mobility is comprised of a variety of providers including the Metropolitan Transit Commission (MTC), private taxi operators, a nonprofit group, and a private bus operator. All services are coordinated through a transportation center which screens applicants, receives trip requests, and allocates the trips among the different providers. No accessible mainline bus services is provided in the Minneapolis-St. Paul area.

In cooperation with its advisory group of elderly and handicapped consumers, the MTC and the Minnesota Department of Transportation (Mn/DOT) developed a certification scheme when

Metro Mobility was first begun in 1979. These procedures required that an eligible Metro Mobility user be an individual that is unable to use or who has extreme difficulty using regular route transit services.

During the 1980 session of the Minnesota Legislature, considerable discussion was held regarding who should be eligible to use Metro Mobility and to what extent there was misuse of the system due to inadequate certification criteria. As a result of these discussions, Mn/DOT was mandated to develop and adopt rules to be used in determining individual eligibility for Metro Mobility. This legislative mandate has set the stage for a review of the existing certification criteria and discussion of what changes could be made to improve the certification process.

B. Alternative Certification Systems

The first step in the development of new Metro Mobility certification criteria was the review of criteria used by other operators to determine eligibility for transit services for the handicapped. Thus, several providers of transportation services for handicapped persons were contacted to obtain information about their certification procedures. Certification procedures used to determine eligibility for specialized transportation services vary widely. Some systems allow any individual over age 65 to use the service in addition to those who are physically handicapped, whereas others allow individuals with only certain types of disabilities to use their system. Yet other operators utilize criteria that deal with specific limitations preventing an individual from using regular route transit service. Some systems require individuals to participate in tests designed to measure mobility, many of which require doctor's verification of an individual's disability. A brief description of the various types of certification schemes used in the systems of Boston, Cleveland, Milwaukee, Portland and Pittsburgh can be found in the Appendix.

C. Limitations of Previous Certification Systems

Although the certification procedures used for Metro Mobility as well as those employed by other specialized transportation providers have a number of advantages in being easy to understand and administer, there are generally one or two important drawbacks. For example, systems using criteria which base eligibility on an individual's actual inability to use regular route transit do not deal with that person's ability to mentally orient him/herself within a transit system. Some systems do not certify individuals who may have a real need for specialized service. Conversely, in other systems where eligibility is based simply on age or on possession of a certain type of mobility aid, individuals who may not actually need special service are being certified to use it, or being assigned to a more expensive type of service than they actually need.

The previous Metro Mobility certification procedure represented one of the more liberal registration models. Specific limitations experienced in the use of those procedures follow in an effort to further emphasize the importance of ealing with functional limitations.

A variety of issues and problems arose with regard to the previous Metro Mobility certification system. Responses on the application form regarding an individual's disability did not specifically indicate if an individual could use regular route transit service rather than Metro Mobility. In many cases, one could make some obvious conclusions from an individual's response. For example, if an individual used a wheelchair, it was safe to assume that (s)he was not able to board a mainline bus, since regular route buses are not equipped with lifts in the Twin Cities area. However, in a case where an individual used some other mobility aid, such as a cane or crutches, or used no mobility aid, it was impossible to tell from the application form whether or not a person could in fact, use regular route transit services, or whether it was simply an inconvenience for him/her to do so. There were no questions designed to gather information regarding that individual's functional limitations, only questions designed to determine if they were in some fashion, disabled.

Another area of concern with the former certification system was that persons who became certified to use Metro Mobility were entitled to use Metro Mobility services throughout the year. There was some evidence to support the assertion that many handicapped individuals require the use of a specialized transportation system only during portions of the year. For example, during the winter months, individuals with certain types of lung and/or heart problems need Metro Mobility services but are able to use conventional transit services during the remainder of the year.

Finally, there was concern with the former certification system in that specific information about registrants, such as age, visual, hearing or mental disability and information regarding additional assistance needed, was not specifically requested. This lack of information made it difficult for transit operators to identify and provide appropriate assistance to their passengers.

III. ISSUES IN THE DEVELOPMENT OF ELIGIBILITY CRITERIA

In reviewing both the previous certification system used in the Minneapolis-St. Paul metropolitan area as well as the procedures employed in other metropolitan areas, certain issues in setting up a new system became apparent. At the heart of those issues was a need to clarify the purpose, or need, of a certification procedure.

A. Purpose of a Certification System

The purpose of establishing eligibility criteria for special transportation services, as it has been defined in the Minneapolis-St. Paul metropolitan area, is to make sure that persons with mobility limitations receive the most appropriate transportation. A transportation service can be defined as "appropriate" if it meets a person's special needs in overcoming mobility barriers and:

- requires the least public subsidy, and
- causes the least possible inconvenience to the user

Promoting appropriate transportation services is to some extent the positive version of controlling or eliminating "abuse". Under the previous Twin Cities certification system, abuse only occurred if a person used Metro Mobility without being certified. If a certified person who could ride the mainline bus used Metro Mobility, it could not be called an abuse. Rather, it was an inappropriate use of transportation services since the person could ride mainline buses at a lower subsidy. The most appropriate transportation mode could be accessible van or small bus, taxi, carpool or vanpool, and either accessible or inaccessible regular route transit.

B. Functional Limitations as the Basis of a Certification System

As discussed above, many systems base a person's eligibility upon the type of disability present (e.g., blindness or mobility aid used e.g., wheelchair, crutches, walker). This approach can be misleading because, expanding on the above example, many blind people can, with training, learn to use a regular route service, and some persons using crutches will be able to reach a bus stop independently and wait for the bus while others using crutches may not. The same distinction applies to wheelchair users living in cities with accessible mainline service available.

C. Procedures for Gathering Information on Applicants

The certification systems, previously summarized, vary significantly from one another, ranging from what was essentially a self-certification system in Minneapolis-St. Paul to the use of an examining commission and of simulated bus steps in Pittsburgh. All systems try to resolve the conflicting needs of collecting accurate information, respecting the dignity of the applicants, and completing the screening process within reasonable time and expense. Trade-offs in all these areas must be made in an effort to exert control and yet not incur major expenses.

IV. HOW THE NEW CERTIFICATION SYSTEM WORKS

A. Eligibility

Efforts have been made to more narrowly define eligible Metro Mobility users as those who cannot use regular route transit service and to deal with the issues presented in the preceding section. Four basic criteria were developed, and are discussed below.

1. Inability to maneuver oneself at least one-quarter mile

The general spacing of regular route bus routes within the Minneapolis-St. Paul metropolitan area is 1/4 mile. Therefore, if an individual is able to walk at least 1/4 mile, (s)he should be able to use regular route service provided that (s)he does not meet any of the other eligibility criteria. Data indicates that more than 90% of the current Metro Mobility users live within three blocks of a bus stop.

2. Inability to go up and down the bus steps of a mainline bus

The inability to go up and down the bus steps of a standard forty-foot bus can obviously limit one's ability to use regular route transit. Therefore, if an individual cannot climb 16 inches from the ground to the first bus step, (s)he would be eligible to use Metro Mobility.

3. Inability to wait outside for ten or more minutes

Research on current travel patterns indicates that approximately 80% of the trips currently taken on Metro Mobility requires a wait of 10 minutes or less at either the first boarding or any subsequent transfer if made on regular route bus lines. If a current Metro Mobility user was able to ride regular route service, (s)he would not usually have to wait more than 10 minutes for the vehicle to arrive, especially in the two central cities.

4. Inability to use or learn to use mainline bus service due to a mental impairment or learning disability

Although the range of mental disabilities may vary considerably, it appears that a majority of individuals with these types of disabilities can be trained to use regular route transit service with few problems. With the assistance of a trained Mobility Specialist currently working with the mentally handicapped, questions were developed to determine if an individual with a mental handicap could use regular route transit service.

Additionally, the individual's need to use Metro Mobility year-round, and the availability of regular route transit training influence the way in which an individual is certified.

B. Conditional Certification

Conditional certification is granted to individuals who are not currently able to use regular route transit service, but could do so after training. This type of certification is granted for a period up to eighteen months, at six month intervals, to allow individuals the opportunity to receive appropriate training.

In determining eligibility, consideration is also given to the verification required in most cases by the appropriate professional. A discussion of the verification procedures follow.

C. Verification

Verification of an individual's disability by a physician, a certified physical therapist or a licensed psychologist is required for all individuals except those in wheelchairs or those who require lift-equipped service.

In the past, verification of eligibility for Metro Mobility was required only when the individual had a "non-visible" disability. It has been the perception of many that by not requiring more extensive verification, more individuals have been certified to use Metro Mobility than actually require the service. Furthermore, some groups representing disabiled individuals have indicated that the concept of a verification is not popular with the handicapped community, and that, in many cases, a doctor doesn't maintain the type of data that would enable him/her to determine the necessary eligibility characteristics. Others have alternatively suggested that verification is absolutely necessary to ensure that individuals are matched with the appropriate forms of transportation.

There are many ways to verify an individual's disability, ranging from a very controlled process whereby applicants would be screened by a board and asked to actually demonstrate their ability to use regular route transit service, to a very relaxed process whereby a person's statement would be considered sufficient for eligibility.

The verification procedure defined above represents a "middle ground" position that seems to be effective but not extremely costly, complicated, or degrading to the individuals requesting certification. Its effectiveness comes from obtaining the same information from two different sources (the applicant and the health professional), and from asking specific questions on functional limitations affecting transit use. The option of using different types of health professionals should make it easier for applicants.

D. Appeals

Any individual who has been determined to be ineligible to use Metro Mobility has the opportunity to appeal that decision first to the Manager of Metro Mobility, and secondly, to an Appeals Board. This Appeals Board is made up of three individuals -- a Metro Mobility user, a disabled regular route transit user and a medical technician. This composition was selected to ensure that individuals would be familiar with functional limitations associated with disabilities and yet provide a variety of perspectives on that subject.

E. Seasonal Certification

A seasonal certification status allows eligible individuals to use Metro Mobility between November 1 and April 15. It has been added in an effort to recognize that while the disabilities of some individuals prevent them from being able to wait outside in below freezing temperatures, or able to navigate on icy and snowy sidewalks, etc. -- conditions common to Minnesota during the winter months -- they are often able to use regular route transit during the warmer months of the year.

V. HOW THE NEW CERTIFICATION PROCEDURE EVOLVED

A. Public Involvement

In order to develop more effective criteria for individual eligibility to use Metro Mobility, a number of metro area organizations needed to be directly involved in the discussion. Mn/DOT Transit Administration Staff organized a Certification Task Force (CTF) to serve this function. The CTF included both agency and consumer representatives. This Task Force began regular meetings early in January, 1981. By early March, the Task Force had completed its task.

During the months of January and February, members of the Certification Task Force made presentations or consulted with ten user advocacy groups. The certification procedures went through a state rule making process. The Adopted Rules were published in the State Register in August, 1982.

B. Recertification Process

In May, 1983, over 21,000 individuals certified to use Metro Mobility were notified by mail that in order to continue to be eligible to use Metro Mobility, they would need to re-apply and meet the newly established criteria. About 16%, or 3,500 of these letters were returned to the Metro Mobility Transportation Center either because the individuals were deceased or had moved.

As of June, 1984, approximately 9400 individuals had been certified to use Metro Mobility. Of those, it is estimated that 7,000 were previously certified to use the service and now have been recertified.

VI. IMPACTS

Meeting users' special transportation needs in the most appropriate and cost-effective method has been the guiding philosophy and purpose in developing and implementing the Metro Mobility recertification effort. The authors of this paper and the implementers of the program consider the philosophy of basing certification on functional limitations a sound approach for dealing with certification issues, although there have been new issues to surface during the implementation of these new procedures. The purpose of this section of the paper is to identify the impacts of the recertification effort upon the effected users and their travel patterns.

A. User group

In January, 1983, 19,800 persons were registered to use Metro Mobility service. In June, 1984, about a year following the initial recertification mailing, there were 9,400 individuals certified to use the service. As mentioned earlier, approximately 3,500 of these individuals had either moved or were deceased. Of the 9,400 individuals currently certified to use the service, it is estimated that 7,000 of these individuals were continuing certified users of the service.

It can only be speculated why the remaining 6,900 individuals are no longer certified to use the service. In the early years of Metro Mobility service, a major marketing effort was made to notify consumers about the service and to encourage them to sign up to use it. It is now the feeling that many of those who originally became certified for the service never did actually use it, and that when they received the recertification materials, they chose not to complete the forms. It is further thought that some of those previously registered to use the service may have realized that they would no longer be eligible and chose not to complete the forms. The data necessary to document these speculations was not collected, and, therefore, we can draw no firm conclusions regarding either who is no longer using the service or who is still using the service.

What is apparent from the limited data available, is that most user types, as categorized for operational purposes, make up about the same percentage of the total ridership as they did a year earlier, even though the total number of those registered has declined by over 50%. The only category where there appears to be a substantially lesser percentage of ridership is that of "65 years of age or older and cannot walk to a bus route." See Figure 2. At the same time, the only category where there appears to be a marked increase in registrants is the category represented by "Use a wheelchair, require a lift or ramp-equipped vehicle and do not require an escort." While clearly this is not conclusive evidence of a change in the type of passengers carried by Metro Mobility, it could indicate that perhaps those without a specific functional disability chose not to be recertified and that those who do have functional limitations are now beginning to make up a larger portion of the clientele being served.

B. Ridership consequences

While the total number of individuals certified to use Metro Mobility service has declined by over 50% during the year, ridership, on the other hand, has continued to increase. Between January, 1983 and June, 1984, the number of monthly rides on Metro Mobility has increased by about 20%. It is difficult to isolate a specific cause, for this growth, especially since, at the same time, the dispatching functions at the Metro Mobility Transportation Center were being computerized and transit ridership generally in the Twin Cities seemed to be on the rise in response to improved economic conditions. However, it is the impression of many involved with the program that the recertification mailing to all users served as a kind of marketing campaign to stimulate greater use of the service, thus explaining at least part of the ridership increase.

C. Data Base

One of the secondary goals, but primary impacts of the recertification efforts has been the refinement and greater availability of data to be used in day-to-day operations. Specific information on clients, including age, blindness, and deafness, now appears on the record that is used when developing trips for eligible individuals and, as a result, Metro Mobility is able to provide better and more responsive service to its users. Furthermore, updated information about individuals' disabilities, addresses, need for escorts, etc.,is being collected.

D. User conflict

At the outset, the guiding purpose of the new certification system was to insure that persons with mobility limitations received the most appropriate transportation. Transportation service was "appropriate" if it met:

- a person's special needs in overcoming mobility barriers;
- required the least public subsidy; and
- caused the least possible inconvenience to the user.

Further, the certification system was designed to better match a particular functional limitation with the most appropriate form of service mode, i.e. accessible van or small bus, taxi, car or vanpool and regular route bus.

It was in matching up of a person's functional limitation that some significant problems surfaced. For instance, a number of elderly blind persons disagreed with the fourth criteria that required the applicant to verify that they had a learning disability. Also, it is believed that the fourth criteria, as presently administered, enables increased use of Metro Mobility service by people with mental impairments who formally used mainline bus service.

This issue impacts mainly those blind persons who are frail and elderly. Because of the negative reaction registered by a number of people who feel that this criteria is not appropriate, an appeal was made to the Minnesota Legislative Commission to Review Administrative Rules (LCRAR) to change the criteria to require the applicants to undergo screening by a mobility specialist, to better ascertain their capabilities in this area. The LCRAR recommended that the Administrative Rules process be amended to deal with this concern. Consequently, the ongoing issue of whether blindness is or is not a functional disability, will be again debated in the public hearing which is part of the rule amendment process.

This process will provide an opportunity to deal with both issues that touch the blind and mentally impaired.

In the issue related to mental impairments, it is hoped that a more refined set of questions can be developed by a number of people expert in this field that will ultimately channel users to the most appropriate service mode.

CONCLUSIONS

The recertification process has helped those involved with Metro Mobility to develop a sound philosophy and service organization for dealing with issues associated with certification. However, there have been some unforeseen circumstances, in addition to positive results. For those with blindness as a disability, the issue of certification is not yet resolved. Looking back over the steps in getting community involvement in the setting up of this new criteria, it appears that a more intensive effort could have been made to bring the forces for and against automatic certification for the blind into a face-to-face collaborative problem-solving situation. As previously stated, the parties involved in the forthcoming Metro Mobility rules amendment process will certainly face this issue head-on again. The answer or solution to this difficult issue can be positively approached provided a skillfully organized and managed open problem-solving process gets initiated with opposing parties fully involved in seeking a solution.

A number of positive outcomes have resulted from the recertification process. The most significant comes as a result of the detailed data base now established for each user's divididual disability characteristics. The Metro Mobility Transportation Center dispatcher is now more aware of a person's precise physical requirements so that appropriate driver and/or system response occurs.

Another major result has been the heightened awareness of the overall program through the actual recertification process contacts. People seem to be better informed about what types of services are available on the basis of functional mobility limitations.

The recertification effort in the Twin Cities metropolitan area resulted in about a 50% decrease in the number of individuals certified to use the service. This decline would have been reduced to about 40% had Metro Mobility purged its files in earlier years. It appears that many individuals who had been previously certified to use the service either self-determined that they were no longer eligible to use the service or that they never did actually ever use the service, and thus chose not to complete the forms necessary to become recertified. Only about 2 to 3% of those applying for recertification were rejected, and of those, over 50% were rejected because their stated disability was blindness, a condition not allowed for in the rules, as a functional limitation.

Although the number of individuals certified to use Metro Mobility service has declined significantly, the system ridership continues to grow. Although difficult to pinpoint the reasons for this ridership growth, there is some evidence to suggest that the recertification mailing and subsequent public discussion served to remind users that the service existed, and thus prompted them to either begin using it or increase their usage.

Additionally, the establishment of a certification philosophy based on an easy to understand functional mobility philosophy has promoted and will continue to promote an effective method of matching the mobility limitation with the most appropriate available transportation mode. Finally, it is generally held by the various impacted agencies and operators of the program that this scheme produced a positive response from the users, as well as from the people who now must make it work in the day-to-day operation of Metro Mobility.

Exhibit 1

Certification Procedures Used in Various U. S. Cities

1. Boston--Specialized transportation services in Boston are operated by Transporting Handicapped and Elderly in Massachusetts, a private, nonprofit agency under contract to the Massachusetts Bay Transit Authority (MBTA). Lift-equipped buses and vans are used to provide transportation to handicapped persons who are not able to make use of conventional transit services. To become certified for service, an individual must make application to MBTA. Individuals must state whether they cannot perform or have great difficulty performing any of the following activities:

   a. using stairs or escalators
   b. reading information signs
   c. riding a regular bus
   d. standing in a moving vehicle
   e. hearing announcements or spoken directions
   f. walking more than 200 feet

Three certification classifications were developed for service priority, based on the applicants' responses. Individuals in category one use wheelchairs, and receive first service priority. Category two consists of individuals who have extreme difficulty using regular transit services. Individuals in this category generally find it difficult or impossible to perform two or more of the above-mentioned activities. All other handicapped individuals are certified under category three, and receive lowest service priority. A doctor's description of an individual's disability and signature may be required in some situations.

2. Cleveland--The Greater Cleveland Regional Transportation Authority operates two types of transportation services for the elderly and handicapped -- Paratransit and Extra Lift. Paratransit service generally operates largely during the non-peak hours. Anyone 65 years or older or disabled is eligible for Paratransit service. Identification cards are issued for regular route reduced fare and Paratransit service. Thus, disabled persons who are able to use regular route service are also eligible to use Paratransit services. The Extra Lift service operates largely during the peak hours, and consists of standing order service for work and school. Eligibility is restricted to severely disabled persons who cannot climb stairs, walk 100 yards, or withstand temperatures lower than 20° F. Eligible individuals must be referred by a doctor or rehabilitation agency.
3. Milwaukee-The Milwaukee Transit Authority contracts with three taxi companies and three for-profit transportation providers to provide user side subsidy transportation services to handicapped persons in the Milwaukee area. Eligibility is restricted to individuals using wheelchairs, walkers, crutches, long-leg braces, and those who are legally blind. Applications must be signed by a doctor or health professional.
4. Portland--The Lift, operated through Tri-Met, the transit agency contracts with three not-for-profit or government agency carriers to provide service in the three counties in the service area. Residents who are physically or mentally unable to use regular transit, and, clients of participating agencies. Users are allowed to certify themselves as eligible.
5. Pittsburgh--The "Access Transportation Service," which operates in Allegheny County, contracts with private transportation providers and taxi companies to provide accessible and non-accessible service to handicapped persons in the area. Anyone who is over sixty years

of age or is handicapped is eligible for service. Fare is determined by trip length. Severely handicapped individuals are eligible for a 75% discount on fares. Eligibility for the reduced fare service is restricted to handicapped persons who cannot board a regular bus. An access staff person conducts the initial certification interview, and refers the potentially certifiable applicant to the Easter Seals Society. A physical therapist employed by Easter Seals uses a model of the front part of a bus to determine if an individual is able to climb stairs. An individual who is able to climb the stairs, even with great difficulty, is not eligible for the discount.

Exhibit 2

NUMBER OF METRO MOBILITY CONSUMERS BY CERTIFICATION CATEGORY

		FOR PERIOD ENDING JANUARY 31, 1983		FOR PERIOD ENDING JUNE 7, 1984	
	Category	Number Certified	Percent Certified	Number Certified	Percent Certified
38	65 years of age or older and cannot walk to a bus route	2,742	13.8	633	6.9
36	Do not use a wheelchair or personal assistance device, can travel in an auto and require an escort	1,392	7.0	492	5.2
35	Do not use a wheelchair or personal assistance device, can travel in an auto and do not require an escort	4,175	21.1	2,087	22.2
34	Use a personal assistance device, can travel in an auto, and require an escort	1,506	7.6	370	3.9
33	Use a personal assistance device, can travel in an auto, and do not require an escort	5,179	26.1	2,530	26.9
24	Use a personal assistance device, require a lift or ramp equipped vehicle and require an escort	171	0.9	32	0.3
23	Use a personal assistance device, require a lift or ramp equipped vehicle and do not require an escort	255	1.3	105	1.1
32	Use a wheelchair, can travel in an auto, and require an escort	506	2.6	217	2.3
31	Use a wheelchair, can travel in an auto, and do not require an escort	615	3.1	549	5.9
22	Use a wheelchair, require a lift or ramp equipped vehcile and require an escort	1,673	8.4	933	9.9
21	Use a wheelchair, require a lift or ramp equipped vehicle and do not require an escort	1,601	8.1	1,416	15.0
00	Conditional Certification: Persons who are in need of temporary special transportation until trained to use mainline bus service			32	0.3
TOTAL CERTIFIED		19,815	100.0	9,396	100.0

J. S. REVIS & ASSOCIATES, INC.

A LOW COST APPROACH FOR IDENTIFYING & EVALUATING SERVICE ALTERNATIVES FOR ELDERLY AND DISABLED PERSONS

CHARLOTTE, NORTH CAROLINA

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A LOW COST APPROACH FOR IDENTIFYING & EVALUATING SERVICE ALTERNATIVES FOR ELDERLY AND DISABLED PERSONS

CHARLOTTE, NORTH CAROLINA

The Charlotte Technical Assistance Project is an UMTA-funded project aimed at increasing the mobility of disabled persons. The project was initiated to offer expert assistance to selected transportation providers in order to improve or expand their services to the disabled. The Metrolina Independent Living Center (MILC) was selected as one out of four recipients of technical help (sites in Minnesota, New Hampshire, and Michigan were also selected).

A technical assistance team from J.S.Revis & Associates and Harold Russell Associates, working with the MILC, the City of Charlotte and Mecklenburg County,designed a technical assistance project whose specific objectives were to identify and define a number of transportation alternatives that could be used to improve the mobility of the disabled in the Charlotte area. Each alternative was evaluated in terms of the level of service provided, cost effectiveness and the relevance of the alternative to the needs and perceived desires of the disabled (e.g., the quality of the service).(Table A)(Table 1)

To undertake this task, a survey of City and County human service agencies was conducted. From the survey, four options were identified and selected for more detailed analysis. These options included: (1) an expansion of the present STS system by adding four more vehicles(as planned by the City); (2) expansion of the STS system so that its service area includes the City and the County; (3) an MILC proposed accessible fixed-route and scheduled system operating within 4 quadrants in the City of Charlotte;and (4) the development of a Coordinated Human Service Agency Transportation Center to more effectively use the existing transportation services and resources provided by the human service agencies in the area.(Table A)

The alternatives analysis did not include an evaluation of the cost-effectiveness of making the present Charlotte Transit System accessible. The decision to exclude this option was based on two considerations: (1) because of the limited budget available for analysis and assistance,the MILC in conjunction with the Technical Assistance Team, decided to concentrate effort on the four options described, and (2) since a decision had already been made by the City to provide special services using STS (rather than mainline accessibility), it made a geat deal more sense to evaluate the proposed STS expansion against alternative special service options.

The operating characteristics of each alternative were simulated and evaluated in terms of four criteria: (1) the degree of independence and mobility generated; (2) maximization of trips and service coverage, (3) cost effectiveness, and (4) the quality of service. The key findings of the evaluation have been summarized in Table ES-1. A number of these conclusions warrant highlighting. (Table 2 Simulation Summary)(Table 3 Detailed Operating Assumptions)

- In terms of the target population of disabled reached by the respective alternatives, the extension of the STS to include the County (Alternative II) provides the greatest coverage -- about 17.4 thousand people 15 years or older with mobility impairments.

- Measured in terms of seat-miles and wheelchair-miles per day, the fixed route grid system (Alternative III), not surprisingly because of its fixed route and scheduled character, provides the highest level of seat-mile service (182 thousand seat-miles per annum). On the other hand, in terms of wheelchair seat-miles, Alternative II provides the greatest volume of service (although the rural character of the County to a considerable extent explains this high level wheelchair seat-miles).

- Measuring mobility in terms of the estimated number of passenger trips per 1000 disabled persons, the grid system shows the highest level of usage at 14 trips; the STS city-wide and the county-wide service options provide about 8 trips per 1000.

- Measured in terms of one-way trips per day, the performance of the grid system (with an estimated 190 one-way passenger trips per day) shows the greatest degree of utilization -- about 35 percent higher than the county-wide STS alternative and almost double the proposed current STS expansion (Alternative I).

- The more extensive service area of Alternative II (county-wide STS service) is reflected in the 545 square miles that includes the County and City. One result of this substantially increased area is a relatively low level of vehicle miles (2.5) per square mile of service area (in contrast to Alternatives I and III). For the coordination alternative (Alternative IV), it has been assumed that both County and City agencies would participate.

- Cost-effectiveness has been measured in three ways: cost per passenger trip, cost per vehicle mile, and cost per vehicle hour. Each has been expressed with and without capital costs and Table ES-1 presents these costs including capital costs. Specific findings follow:

  -- Because of the fixed route and schedules nature of the grid service, it has the highest vehicle mile and the lowest vehicle hour costs. It also has the highest cost per passenger trip and net operating deficit.

-- The currently proposed expansion of STS has the lowest cost per passenger trip ($9.22) and net operating deficit ($223 thousand) and an overall basis balancing service against cost is probably the most cost-effective alternative.

-- In terms of the net operating deficit, all the alternatives generated deficits with the largest associated with the grid system (Alternative III). This alternative generated an estiamted net deficit of $460 thousand per year.

- In terms of the quality of service as measured by its accessibility and convenience attributes, the grid alternative provides the largest seat and wheelchair/tie-down capacity. However, it is also likely to require at least one transfer in order to reach one of the grids or quadrants other than the one in which the rider starts his or her trip. The grid also provided the most frequent service (hourly).

- The analysis suggests that the use of a smaller vehicle (e.g., a van or small bus) for the grid system would result in a more favorable cost-effectiveness result but not sufficient to alter relative results significantly.

- There appears to be considerable interest and potential for a Coordinated Human Service Agency Transportation Center as the basis for improved mobility and transportation services for the disabled and other clients of these agencies.

- Survey of these agencies indicated they are currently operating about 400 vehicles and spending about $1.4 million dollars on transportation. This estimate is actually low since it only covers the budgets reported by 56 agencies out of the 83 to whom the survey was mailed.

- Out of some 40 agencies responding to questions on their available capacity, about half indicated they had capacity available and were willing to pool or share this capacity in some way. Of related importance is the fact that about 60 percent of the agencies willing pool their capacity were private-non-profit organizations rather than from the public sector.

- The private-for-profit sector added an additional 15 percent of respondents with transportation capacity available and a willingness to share. Their interests, however, were more directly focussed on the sale of these services to human service agencies. They should not be ruled out, however, as participants in coordination. They can play an important role in supplementing agency capacity.

- The survey identified a wide range of interest in coordination activities including training, information sharing, coordinated data and management systems, coordinated vehicle use and maintenance and even centralized dispatching and operations.

- Given the considerable interest and potentials of coordination as indicated in the agency survey, this alternative is worth implementing irrespective of any of the other alternatives evaluated.

RECOMMENDATIONS

From the conclusions enumerated above and other aspects of the technical assistance, a number of important programs for improving the mobility of the disabled (and other target groups) suggest themselves. These strategies for action are present in this section. However, a number of comments are warranted.

To begin with, in terms of the findings of the technical assistance team, it is quite important to remember that the analysis did not examine the option of "mainline" accessibility on the Charlotte Transit System. The findings also must be interpreted in the context of the specific assumptions used in analyzing each of the alternatives.

It should also be quite apparent from the findings summarized in Table ES-1 that each of the alternatives have somewhat difference features; there is typically a "trade-off" between service coverage, frequency, convenience, and costs.

Budget constraints are always an important consideration in transport planning and operations and, unquestionably, were important in planning the present and proposed expansion of STS. The level of the budget is an issue for local consideration and will (or should) reflect local priorities. However, there are always questions of balancing service quality against the amount of service provided. Therefore the simple choice of selecting the lowest cost alternative may not always result in selecting the best option. After all, the lowest cost alternativeis to do nothing.

In the context of these considerations, there is no single clear choice that overwhelmingly dominates all the others. Trade-offs will need to be made and the following recommendations are provided in order to suggest strategies that warrant serious consideration.

1. In view of the strong interest shown in coordination by the agencies surveyed, the development of a coordination center warrants implementation irrespective of any action taken on the other alternatives.

2. It is recommended that the City develop a coordinated agency transportation program working with Mecklenburg County in their present effort. A general strategy for such an effort has been described in the Main Report. A generalized description for a lease rental approach has also been included (in the Annex) for further guidance.

3. On an overall basis, balancing costs and service, the presently proposed service expansion of STS appears to be the most cost effective approach. However, the addition of four vehicles does not appear to be sufficient to provide an adequate level of service and it is recommended that the expansion be increased to add at least one or two more vehicles. The scope of the addition should be set in the context of potential capacity that might be made available from a more coordinated effort among human service agencies currently providing transportation to clients.

4. The increment of cost associated with extending STS to countywide service is estimated to be about $190 thousand. From the point of view of the County, this is probably a relatively lower cost than instituting a service separately. For the City, there would be added wheelchair and vehicle capacity. It appears worthwhile for the City and County to consider negotiating a cost-sharing scheme based on mileage and administrative cost criteria.

5. The optimum scenario for improved service appears to be the development of an integrated approach that includes coordinated agency transportation services currently supported by City and County funds. These public agency transportation services could be used as a core for a regional transportation coordination center that would serve as a central clearing house and point of activityfor public, private, and private-non-profit transportation. In that context, it is recommended that the City and County organize a joint planning group comprising interested agencies and potential participants. Because of its on-going regional network with City and County agencies, the MILC could be an important focal point for this effort.

6. One service aspect not considered by the Technical Assistance Team was the development of a feeder service for the Charlotte Transit System with selective lift bus implementation. In addition, several cities have implemented "On-Call", fixed route, scheduled accessible transit service on regular transit. Both concepts warrant further exploration. Illustrative material from one "On-Call" service has been included in the Annex.

Table ES-1
CHARLOTTE TECHNICAL ASSISTANCE PROJECT
SERVICE ALTERNATIVES ANALYSIS

SERVICE CRITERIA EVALUATION MEASURES

Alternative Evaluated	Independence and Mobility			Maximize Trips and Geographic Coverage			Cost Effectiveness of Service (Excluding Capital Costs)				Service Quality				
	Target Population 15 Years Or Older (With Mobility Impair'nts)	Seat Miles Per Day / WC Seat Miles Per Day	Passenger trips/ 1000 Disabled Persons	No. of One-Way Passenger Trips Per Day	Service Area Coverage In Square Miles	Daily Vehicle Miles Per Sq. Mi / Dly Rte Miles Per Sq.Mile	Cost/ Passenger Trip	Cost/ vehicle mile	Cost/ vehicle hour	Net Op. Deficit Per: Day Year Trip	Average Headway	Advance Reservation Requirement	Total No. Wheelchair tie-downs[1]	Total No. of seats[1]	No. of transfers
Alternative I. STS Service Expansion (as planned)	13,550	19,840 9,920	7.75	105	143.3	4.3 N/A	$9.22	$1.56	$25.49	$ 879 $223,000 $ 8.36	N/A	48 hours	16	40	not required
Alternative II. STS Service Expansion (county-wide)	17,350	66,720 33,360	8.07	140	545.90	2.5 N/A	$11.84	$1.23	$29.39	$ 1582 $402,000 $ 11.30	N/A	48 hours	24	60	not required
Alternative III. Fixed Route Grid System	13,550	182,160 24,28	14.02	190	143.30	5.3 .41	$12.43	$2.59	$20.51	$ 1807 $460,000 $ 9.51	1 hour	N/A	32	240	maximum of one
Alternative IV. Coordination Center or Brokerage System	17,350	unknown	unknown	unknown	545.90	unknown	unknown	unknown	unknown	unknown	unknown	unknown	10	est. 960 [2]	unknown

N/A Not Applicable

[1] Based on active fleet only

[2] Excluding sedans and stations wagons owned by 3 reporting cab companies (survey results)

SOURCE: J.S. Revis & Associates, Inc.

Table A

CHARLOTTE NORTH CAROLINA TECHNICAL ASSISTANCE
TECHNICAL ASSISTANCE OBJECTIVES
SERVICE ALTERNATIVES
EVALUATION CRITERIA
LEVEL OF EFFORT

OBJECTIVES

1. To identify and define a number of transportation alternatives which could be used to provide increased mobility to the disabled in the City of Charlotte and, where relevant, Mecklenburg County.
2. To evaluate each alternative according to:
   - the level of service provided in terms of quality and quantity of the service,
   - the cost effectiveness in terms of the cost for specific levels of service, and
   - the relevance of the alternative to the transportation needs and perceived desires of the disabled.

SERVICE ALTERNATIVES

I Improved STS - same service area, additional vehicles

II Improved STS - service area expanded to include Mecklenburg County and additional vehicles

III Grid System - based on MILC proposal

IV Coordinated Human Service Transportation System - based on survey results.

EVALUATION CRITERIA

1. Degree of increased mobility and independence,
2. Number of trips and service area covered,
3. Cost effectiveness, and
4. Quality of service.

LEVEL OF EFFORT

2.5 Person Months of Input-TA Staff
3.2 Person Months of Counterpart Support
Estimated Total Cost $15,000 -TA Staff & Travel

Table 1

CHARLOTTE TECHNICAL ASSISTANCE PROJECT
SERVICE ALTERNATIVES ANALYSIS

Evaluation Criteria

1. Independence and Mobility
   - Potential number of disabled to be served
   - Seat miles per day
   - Wheelchair seat miles per day
   - Passenger trips per 1000 disabled persons
2. Maximization of Trips and Service Coverage
   - Number of one-way passenger trips
   - Service area coverage in square miles
   - Daily vehicle miles per square miles
   - Daily route miles per square miles
3. Cost Effectiveness
   - Cost per passenger trip
   - Cost per vehicle mile
   - Cost per vehicle hour
   - Net operating deficit per day/year/trip
4. Service Quality
   - Average headway
   - Advance reservation requirement
   - Number of wheelchair positions
   - Number of seats
   - Number of transfers

CHARLOTTE TECHNICAL ASSISTANCE PROJECT
SERVICE ALTERNATIVES ANALYSIS

Summary of Simulation of Alternatives

VARIABLES	ALTERNATIVE I. STS SERVICE EXPANSION AS PLANNED		ALTERNATIVE II. STS EXPANSION COUNTY-WIDE		ALTERNATIVE III. FIXED ROUTE GRID SYSTEM		ALTERNATIVE IV. COORDINATION CENTER OR BROKERAGE SYSTEM	
BASIC CHARACTERISTICS								
System Coverage (square miles)	143.30		545.90		143.30		545.90	
Total Population	315,473		404,270		315,473		404,270	
Estimated No. of Mobility Impaired in Population (16 years and older)	13,550		17,350		13,550		13,550 - 17,350	
SERVICE ASSUMPTIONS								
No. Operating Days/Week (no nights or weekends)	5		5		5		As per agreement (could be 5 or more)	
No. Vehicles							40 agencies reported 21 having 402 vehicles; 17 agencies willing to share or pool 81 vehicles	
Active	4		6		8			
Spares	2		1		2			
) System Capacity (Active Fleet Only)								
Seats	40		60		240		Est. 960	
Wheelchair Spaces	16		24		32		Unknown	
OPERATING STATISTICS								
1) One-Way Passenger Trips/Day	105		140		190		unknown	
2) Total Vehicle Miles/Day	620		1,390		759		unknown	
3) Total Operating Hours/Day	38		58		96		unknown	
4) Total One-Way Passenger Trips/Mile	.17		.10		.25		unknown	
5) Total One-Way Passenger Trips/Hour	2.75		2.41		1.98		unknown	
6) Headway	N/A		N/A		Average: 1 hr.		unknown	
7) Advance Reservation Reqts.	48 hours		48 hours		N/A		unknown	
D. ESTIMATED COSTS AND REVENUES	With Capital	Without Capital	With Capital	Without Capital	With Capital	Without Capital		
1) Total Costs	$282,000	$246,000	$475,000	$433,000	$600,000	$500,000	$50,800--$75,000	
2) Total Cost/Day	1,100	968	1,870	1,705	2,362	1,969	200	300
3) Total Cost/Vehicle Mile	1.79	1.56	1.35	1.23	3.11	2.59	unknown	unknown
4) Total Cost/Hour	29.22	25.49	32.24	29.39	24.61	20.51	"	"
5) Total Cost/One-way Passenger Trip	10.57	9.22	13.00	11.84	12.43	10.36	"	"
6) Total Revenue	22,670	22,670	31,090	31,090	41,021	41,021	"	"
E. ESTIMATED NET OPERATING DEFICIT	259,330	223,300	443,910	401,910	558,979	458,979	none	none
1) Total Operating Deficit/Day	1,021	879	1,748	1,582	2,201	1,807	"	"
2) Total Operating Deficit/Pass/Trip	9.72	8.37	12.14	10.99	11.58	9.57	"	"
3) Total Operating Deficit/Vehicle Mile	1.65	1.42	1.26	1.14	2.90	2.38	"	"

Table 3

CHARLOTTE TECHNICAL ASSISTANCE PROJECT
SERVICE ALERNATIVES ANALYSIS

Key Service & Operating Assumptions

ALTERNATIVE I:STS CITY-WIDE EXPANSION

1.Levels of Service

- No change in service coverage from current STS service
- The largely subscription character of the present STS service remains much the same with the level of demand largely set by supply constraints
- The advance reservation time remains at 48 hours
- The system fleet currently designated at 4 active and 2 spares for the proposed expansion was accepted and used for analysis

2.Operating Assumptions

- More vehicles would permit better scheduling and positioning and thereby increase productivity. The improvement was assumed to increase from 2.0 pick-ups per hour at current STS service operating levels to 2.75.
- Better scheduling and positioning would reduce the level of deadheading,and it was assumed thatthe average number of vehicles miles per vehicle per day would decline from the current level of 175 to 155.
- There was an assumed related shift in vehicle miles per passenger trip from 8.75 to 7.75.

ALTERNATIVE II:STS COUNTY-WIDE EXPANSION

1.Levels of Service

- The service area was assumed to increase from 143.3 sq. mi. to 545.9 sq. mi.
- Using 1980 Census Tract data,the added target population to be served in the county was estimated to be 4,000 disabled persons for whom the service would be relevant (15 years or older)

Table 3(Cont'd)

Key Service & Operating Assumptions

- Fleet requirements were estimated to be approximately 6 active and 1 spare.This assumed a somewhat lower spare ratio than Alternative I in order to limit the vehicle purchase requirement to 1 more vehicle.

2.Operating Assumptions

- Trip demands and the distribution of trip ends (origins) was assumed to be directly related to the resident locations of the target population.There were 20 percent in incorporated areas and 80 percent in unincorporated areas

- In terms of distribution of the destination end of the trips,the downtown area was used as a surrogate node for all potential locations within the City of Charlotte.A test of this assumption indicated that it would provide a reasonable basis for simulation.

- Because of the rural area to be served by this alternative, trip lengths,vehicle miles and deadheading were all assumed to increase. The simulation indicated that the average number of vehicle miles per passenger would increase from about 8 at the current level of STS service to 16 for Alternative II

ALTERNATIVE III: THE GRID SYSTEM

1.Levels of Service

- Four fixed-route loops were designed to operate a scheduled service within four grids covering the City of Charlotte.

- A common transfer point between each of the loops was provided in the Transit Mall in downtown Charlotte.

- Headways were developed so that the average headway was approximately one hour

- All service was designed to be accessible with each bus having capacity for 4 wheel chairs and 30 regular seats.

- The fleet was estimated to consist of 8 active and 2 spare buses(as per criteria set by the MILC). During the simulation and the analysis thereafter,there were strong indications that a smaller vehicle would be more cost-effective.

Table 3(Cont'd)

Key Service & Operating Assumptions

ALTERNATIVE III:GRID SYTEM

2.Operating Assumptions

- The system was assumed to operate independently of CTS with its own staff and management
- Fares were assumed at the current STS level of 85¢ per trip
- Costs were simulated using city wage levels for system staff and operations and CTS unit costs for other vehicle operating and maintenance costs
- Staff requirements consisted of 13 operators(8 full-time and 2 part-time),a Manager,Director of Maintenance,Supervisor of Operations and administrative support.
- To assure comparability with the other alternatives, 254 days was used as a service operating factor.This assumes that the Grid System would operate on a level comparable to Alternatives I and II.

Table 4

CHARLOTTE TECHNICAL ASSISTANCE PROJECT

SERVICE ALTERNATIVES ANALYSIS

Alternative I: Planned STS Expansion

Costs, Revenues, Operating Statistics	Daily	Annual[1]
A. Estimated Costs and Revenues[2]		
1. Total Costs (without capital)	$968	$246,000
a. cost/vehicle mile	1.56	1.56
b. cost/vehicle hour	25.49	25.49
c. cost/one-way passenger trip	9.22	9.22
2. Total Costs (with capital)	$1,100	$282,000
a. cost/vehicle mile	1.79	1.79
b. cost/vehicle hour	29.22	29.22
c. cost/one-way passenger trip	10.57	10.57
3. Total Revenue	$89.25	$22,670
a. revenue/vehicle mile	.14	.14
b. revenue/vehicle hour	2.35	2.35
c. revenue/one-way passenger trip	.85	.85
B. Estimated Net Operating Deficit		
1. Net operating deficit (without capital)	$879	$223,300
a. net op. deficit/vehicle mile	1.42	1.42
b. net op. deficit/vehicle hour	23.14	23.14
c. net op. deficit/one-way passenger trip	8.37	8.37
2. Net operating deficit (with capital)	$1021	$259,330
a. net op. deficit/vehicle mile	1.65	1.65
b. net op. deficit/vehicle hour	26.86	26.86
c. net op. deficit/one-way passenger trip	9.72	9.72

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1) Based on 254 days of operation per year.

2) Revenues based on present STS fare of 85c per one-way trip.

CHARLOTTE TECHNICAL ASSISTANCE PROJECT

SERVICE ALTERNATIVES ANALYSIS

Table 4

Alternative I: Planned STS Expansion (continued)

	Daily	Annual
C. Operating Statistics		
1. Vehicle miles	620	157,480
2. Vehicle hours	38	9,652
3. Operating speed	16 m.p.h.	16 m.p.h.
4. Passengers (one-way passenger trips)	105	26,670
a. passengers/mile	.17	.17
b. passengers/hour	2.75	2.75

CHARLOTTE TECHNICAL ASSISTANCE PROJECT
SERVICE ALTERNATIVES ANALYSIS

Table 5
Alternative II: STS Expansion Including Mecklenburg County Service

	Daily	Annual[1]
A. Estimated Costs and Revenues[2]		
1. Total Costs (without capital)	$1705	$433,000
a. cost/vehicle mile	1.23	1.23
b. cost/vehicle hour	29.40	29.40
c. cost/ one-way passenger trip	11.76	11.76
2. Total Costs (with capital)	$1,870	$475,000
a. cost/vehicle mile	1.35	1.35
b. cost/vehicle hour	32.24	32.24
c. cost/one-way passenger trip	12.90	12.90
3. Total Revenue	$89.25	$22,670
a. revenue/vehicle mile	.06	.06
b. revenue/vehicle hour	1.54	1.54
c. revenue/ one-way passenger trip	.62	.62
B. Estimated Net Operating Deficit		
1. Net operating deficit (without capital)	$1,582	$401,910
a. net op. deficit/vehicle mile	1.14	1.14
b. net op. deficit/vehicle hour	27.28	27.28
c. net op. deficit/ one-way passenger trip	10.91	10.91
2. Net operating deficit (with capital)	$1,748	$443,910
a. net op. deficit/vehicle mile	1.26	1.26
b. net op. deficit/vehicle hour	30.14	30.14
c. net op. deficit/one-way passenger trip	12.06	12.06

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1) Based on 254 days of operation per year.

2) Revenues based on present STS fare of 85¢ per one-way trip.

CHARLOTTE TECHNICAL ASSISTANCE PROJECT

SERVICE ALTERNATIVES ANALYSIS

Table 5

Alternative II: STS Expansion Including Mecklenburg County Service (continued)

	Daily	Annual
C. Operating Statistics		
1. Vehicle miles	1,390	353,060
2. Vehicle hours	58	14,732
3. Operating speed	24 m.p.h.	24 m.p.h.
4. Passengers (one-way passenger trips)	145	36,830

CHARLOTTE TECHNICAL ASSISTANCE PROJECT

SERVICE ALTERNATIVES ANALYSIS

Table 6
Alternative III: Fixed Route Grid System

	Daily	Annual[1]
A. Estimated Costs and Revenues[2]		
1. Total Costs (without capital)	$1,969	$500,000
a. cost/vehicle mile	2.59	2.59
b. cost/vehicle hour	20.51	20.51
c. cost/one-way passenger trip	10.36	10.36
2. Total Costs (with capital)	$2,362	$600,000
a. cost/vehicle mile	3.11	3.11
b. cost/vehicle hour	24.60	24.60
c. cost/one-way passenger trip	12.43	12.43
3. Total Revenue	$161	$41,021
a. revenue/vehicle mile	.21	.21
b. revenue/vehicle hour	1.68	1.68
c. revenue/one-way passenger trip	.85	.85
B. Estimated Net Operating Deficit		
1. Net operating deficit (without capital)	$1,807	$458,979
a. net op. deficit/vehicle mile	2.38	2.38
b. net op. deficit/vehicle hour	18.82	18.82
c. net op. deficit/one-way passenger trip	9.51	9.51
2. Net operating deficit (with capital)	$2,201	$558,979
a. net op. deficit/vehicle mile	2.90	2.90
b. net op. deficit/vehicle hour	22.93	22.93
c. net op. deficit/one-way passenger trip	11.58	11.58

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1) Based on 254 days of operation per year.

2) Revenues based on present STS fare of 85¢ per one-way trip.

CHARLOTTE TECHNICAL ASSISTANCE PROJECT

SERVICE ALTERNATIVES ANALYSIS

Table 6

Alternative III: Fixed Route Grid System (continued)

	Daily	Annual
C. Operating Statistics		
1. Vehicle miles	759	192,786
2. Vehicle hours	96	24,384
3. Operating speed	8 m.p.h.	8 m.p.h.
4. Passengers (one-way passenger trips)	190	48,260
a. passengers/mile	.25	.25
b. passengers/hour	1.98	1.98

CHARLOTTE TECHNICAL ASSISTANCE PROJECT

SERVICE ALTERNATIVES ANALYSIS

Table 7
Alternative IV: Coordination/Brokerage Center

E. Basis For Coordination Agreement

1. Willingness to Coordinate (48 responding agencies) 65% YES

2. Level of Interest In Coordination
(Out of 31 agencies indicating willingness to coordinate)

Activity Level	Percent	Agencies(No.)	Private Non-Profit
• Information Sharing	100%	31	19
• Coordinated Training	76	26	17
• Coordinated Use of Vehicles	61	19	14
• Coordinated Purchasing	55	17	13
• Coordinated Data & Management Systems	45	14	8
• Integrated Funding	39	12	9
• Shared Legal & Other Technical Assistance	35	11	8
• Van/Carpooling Arrangements	35	11	7
• Coordinated Maintenance	32	10	10
• Centralized Dispatching & Scheduling	32	10	7
• Centralized Operation	29	9	6
• Coordinated Vehicle Specs	19	6	5

3. Agencies Indicating Capacity Available (41 responding) 50% YES

4. Client Disability Types Served By Agencies

	Number of Agencies Responding
• Must Use Wheel Chair	21
• Requires Personal Assistance	21
• Use Mechanical Aid	19
• Do Not Need Mechanical Aid or Personal Assistance But Have Some Mobility Problem	22
• Have No Mobility Problems	34

(Total Responding Agencies = 44)

5. Agency Responses to Question: Serve All Requests For Transportation.

	YES	NO
Number	20	35
Percent	36	64

	If No Why Not?
Lack Equip /Drivers/Staff	60%
Lack of Funding	17%

CHARLOTTE TECHNICAL ASSISTANCE PROJECT

SERVICE ALTERNATIVES ANALYSIS

Table 7 (continuing)

Alternative IV: Coordination/Brokerage Center

Costs,Revenues & Operating Statistics	Annual
A.Estimated Costs	$ 50,800 - $ 75,000
B.Estimated Cost Per Agency(20 agencies)	$ 2,540 - $ 3,750
C.Net Operating Deficit	None
D.Operating & Related Data(Estimated)	
1. Operating Days Per Week	5 Or More As Agreed
2. Potential Available Vehicle Base (Survey results)	402 vehicles
3. Vehicle Distribution by Type	232 Sedan/Wagon 74 Vans 48 Large Buses 41 School Buses 7 Small Buses
* 4. Reported Budget For Present (1982) Transportation Services(27 agencies reporting)	$ 1,365,758

a.Distribution: By Budget Size

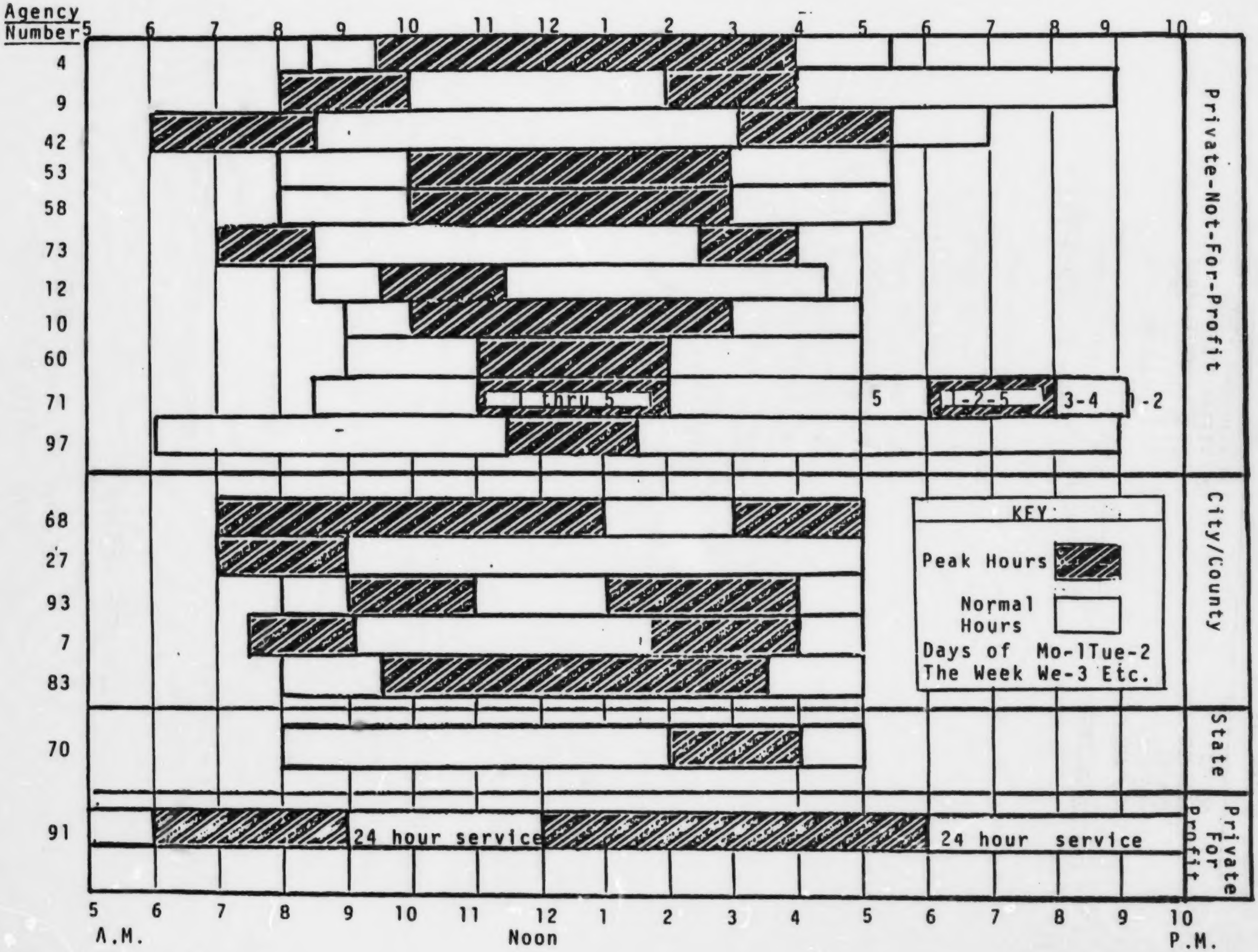
Interval	No. Of Reporting Agencies
Under $10,000	7
$ 10,000 to$ 20,000	8
$ 20,000 to$ 45,000	5
$ 45,000 to$ 55,000	3
$ 55,000 to$175,000	0
$ 175,000 to$250,000	3
$ 250,000 Or over	1
Total Agencies	27

b.Distribution:By Agency Type

Agency Type	No. Of Reporting Agencies	Budgeted Amounts
City/County	4	$ 789,426
State	1	200,000
Federal/Mis.	1	16,450
Private-Non-Profit	20	334,882
Private-For-Profit	1	25,000
Totals	27	* $1,365,758

*Excludes STS Budget

CHARLOTTE TECHNICAL [illegible]
HUM[illegible] SER[illegible]CE [illegible] THE [illegible]GE[illegible] TR[illegible]POR[illegible]
PEAK AND NORMAL HOURS OF SERVICE



ESTIMATING THE DEMAND FOR SPECIAL TRANSPORT FOR DISABLED PEOPLE IN GREAT BRITAIN

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1. INTRODUCTION

Research over the last 10 years or so has shown that elderly and disabled people are heavily dependent on public transport as the majority live in households without cars and many have difficulty walking (see for example Hillman, Henderson and Whalley (1976), Hopkin, Robson and Town (1978), Feeney, Ashford, Morris and Gazely (1979)); even in car-owning households, most are unable to drive and cannot therefore travel independently by car (Hopkin, 1981). Although elderly and disabled people are largely dependent on bus travel for reaching destinations beyond walking distance, they experience a number of difficulties in using buses. In the past, many had difficulty in meeting the cost of bus fares because most are on low incomes,but in much of Great Britain this problem has been alleviated or removed by the provision of concessionary fares (Hopkin, 1984). Physical difficulties with bus travel – getting on and off, moving around inside while the bus is moving, walking to the bus stop and standing waiting at the stop – remain a problem however; in some cases these problems are so severe that people are unable to take advantage of the fares concessions available to them because they cannot use public transport.

A number of developments in the provision of public transport suitable for elderly and disabled people have taken place in recent years in Great Britain. These have involved both modifications to conventional transport, and the provision of a variety of forms of special transport. A number of factors have influenced these developments. There has been an increase in awareness of the transport problems experienced by elderly and disabled people, and groups representing them have become rather more vociferous (although not to the same extent as in the USA for example). Transport operators have realised that elderly and handicapped people now form a large, and increasing, proportion of bus passengers; in Great Britain the National Travel Surveys have shown an increase in the proportion of bus journeys made by people over pensionable age from 11 per cent in 1965 (Mitchell, 1980) to 18 per cent in 1978/9 (Department of Transport, 1983) while in Merseyside, the Passenger Transport Executive found that elderly and disabled people made 20.5 per cent of all bus journeys in 1979/80 and 24.1 per cent in the following year (Rihani, 1982). Legislative changes have encouraged the growth of special transport schemes by relaxing controls on features such as vehicle comfort, service characteristics, charging and advertising. The International Year of Disabled People in 1981 resulted in considerable publicity being given to transport problems, and since then substantial funds from central and local government have been made available for organisations setting up transport schemes, while cheap labour has been available through government-sponsored employment and training schemes. The role of these factors in the growth of special transport is discussed in detail in another paper to this conference (Bailey, 1984).

Apart from the widespread introduction of buses with lower entry steps, developments have been piecemeal and a wide variety of types of transport have been introduced in different parts of the country. Because there has been no up-to-date and comprehensive information on the incidence of transport disability, services have been introduced on the basis of only rough, back-of-an-envelope estimates of the size of the potential market – either in terms of the number of potential users living in the area, or the amount of travel they wish to undertake. The philosophy appears to have been to fund as many types of service as possible, generally on an experimental basis (in that many are subsidised for a limited period initially), and assess the level of demand and the nature of people's travel requirements from the way in which the services are used. A National Advisory Unit for Community Transport has been set up with government funds to advise on operating special transport schemes and monitor their progress. In the future, as experience of these schemes is gained, and particularly if funds become more scarce, there will probably be a tendency to concentrate funds on a few types of provision that are most successful in terms of both the travel requirements they can meet and the cost-effectiveness of their operations.

There is therefore a need for a firm basis for assessing the market for such transport, both to assist organisations in setting up schemes, and for formulating policies on the package of measures that will best meet travel demand within given financial constraints. Questions on transport disability are planned for the next National Travel Survey, but as a step towards making the first national estimates of the market for improvements in public transport for elderly and disabled people, questions on difficulties with using local buses were included in the 1982 General Household Survey (GHS). This is an annual survey of about 20000 people aged 16 and over living in private households in Great Britain. It covers housing, migration, employment, health and education, and is one of the main sources for monitoring social conditions in Great Britain. This paper discusses some preliminary results of the survey and uses them to attempt an estimate of the scale of demand for various types of transport provision. A limited amount of information from other research is included where pertinent, but a comprehensive review of all the evidence available has not been attempted.

2. BACKGROUND

2.1 The incidence of transport disability

The only national source of detailed information on the number of disabled people and their problems is a survey conducted in 1968 (Harris, 1971). This survey provides detailed information on the incidence of various medical conditions and the functional disabilities associated with them, but did not cover difficulties with public transport. It showed that 7.8 per cent of the population over the age of 16 were handicapped. If the rates of incidence among men and women of different ages remained the same this will have increased to 8.4 per cent by 1981, through changes in the age structure of the population. This is over three times the number of people who have registered themselves as disabled with the social services department, so it is clear that there are large variations in the possible size of the disabled population, depending on how disability is defined. On the basis of local studies in Great Britain and more comprehensive investigations in Sweden and the USA for example, Rihani (1982) concluded that probably around

5 per cent of the population of Great Britain (including about 0.3 per cent of the population who are in wheelchairs), experience difficulty using public transport; this was defined as "(a) Persons confined to wheelchairs and those whose ability to walk and climb steps is severely limited because of physical or sensory disabilities involving mainly paraplegics and quadriplegics. (b) Ambulant persons who suffer a temporary or permanent physical or sensory disability which results in hardship or danger in the use of passenger transport services". Some of the people with such difficulties would probably not be defined as disabled in the more usual sense of the term, while others who might be classified as having a disability would have no difficulty with using buses.

One of the most detailed sources of information on transport disability in Great Britain is a survey among a small sample of mobile people who registered as disabled in Coventry. Because the sample was small, and probably concentrated among the more severely disabled but mobile people (because those with more minor problems would be less likely to register themselves as disabled), it cannot be used to estimate the incidence of particular problems, but can be used to indicate their relative frequency. Just over half of the people used buses, mostly with difficulty, and two-thirds of non-users were prevented from doing so by physical difficulties (Feeney et al, 1979). Nearly 80 per cent of bus users had difficulty getting on and off, 90 per cent had difficulty on the bus, three-quarters found standing waiting at bus stops difficult and half had trouble getting to the bus stop (Morris and Gazely, 1977). Table 1 shows the wide variety of problems experienced with the vehicles themselves, and suggests that improving bus design to suit such people is likely to be a complex task.

Research on bus design and bus accidents at Leyland Vehicles in conjunction with TRRL has produced guidelines for bus step heights, preferred seat heights and spacing,designs for handrails, and suggestions for control systems and driver training that could improve journey quality (Brooks, Ruffell-Smith and Ward, 1974; Brooks et al, 1980). Table 2 shows the problems experienced with bus travel by some of the subjects who participated in the experiments. It was estimated that for easy access by 90 per cent of the population, bus steps would need to be 7 inches (17.8 cm) high; step height was therefore considered to be an important factor influencing the use of buses by elderly and ambulant disabled people.

2.2 Developments in transport provision for elderly and disabled people in Great Britain

The Department of Transport has produced a comprehensive guide to transport for disabled people (Department of Transport, 1982), where details of the services available can be obtained. The main types of provision are summarised here. For people who are unable, or virtually unable, to walk the Mobility Allowance is a weekly income supplement intended to cover the additional transport costs involved in being very severely disabled. For ambulant disabled people, a number of types of provision are available.

Following the research on bus design by Leyland Vehicles (Brooks et al, 1974), the introduction of buses with lower entry-steps has become relatively widespread in the past few years; however it will obviously be many years before entire fleets are replaced by these new designs. Another feature which has become fairly common is the reserved seat for elderly and handicapped people near bus entrances to minimise the amount of movement which they have to make inside the vehicle.

Other types of provision are far more localised, involving some form of special transport service. Bailey and Appleby (1983) identified 56 schemes operating in Great Britain in 1983. A directory showing the characteristics of 26 of these schemes (Appleby, 1983) gives detailed information on the type of service provided, so the range of schemes is simply outlined here. In some areas, conventional buses have been adapted to be wheelchair-accessible with lifts or ramps for use on scheduled stage-carriage services which operate on one or two days each week from residential areas into the town centre, so that people living in different parts of the town can all benefit from one or two vehicles. South Yorkshire Passenger Transport Executive operate "kneeling" buses and "split step" buses on some bus routes – essentially two cheap modifications to conventional vehicles that reduce the height of the step for passengers when boarding (for details see Oxley and Benwell, 1983). In some other areas, helpers on the vehicles assist elderly and handicapped people. Because many such people fear poor driving on buses (and they are certainly far more prone to falls and accidents on buses than other passengers (Brooks et al, 1980)), at least one operator (Ribble) has introduced bus services which are always driven by the same person (Taylor, 1982). In addition to these improvements to conventional bus services, a variety of unconventional services have developed, mostly providing a door-to-door service. There are two basic types: dial-a-rides using adapted minibuses and cars in which rides are shared with other passengers, and taxi services. Within these two types of service there are many variations; some provide services to specific destinations such as hospitals or shopping centres while others are as close as possible to conventional public transport in that users can travel to any destination within the area served. Many require advance booking, which means that journeys have to be planned. Most vehicles are equipped with lifts or ramps and have flexible seating arrangements to allow for carrying different numbers of people in wheelchairs, some also provide helpers to assist passengers. In London, a subsidised taxi scheme enables disabled people who can use taxis to travel cheaply (Foulkes and Howard, 1983). Eligibility criteria vary but generally the schemes are for people who are unable to use public transport.

2.3 The General Household Survey

As mentioned earlier, the data described in this paper are preliminary results from the 1982 General Household Survey (GHS). Full details of the survey procedure and the main results are given in the survey report (Office of Population Censuses and Surveys, 1984). The section on bus travel included questions on use of local bus services and difficulties with bus use – due to health problems and for other reasons. Questions were phrased in a way that would elicit spontaneous, unprompted descriptions of people's difficulties described in fairly general terms. Because it is a general purpose survey, people's disabilities were not covered in detail but people with a "long-standing illness, disability or infirmity" which "limits activities" in some way can be identified.

Use of the survey for estimating the demand for disabled people's transport has a number of limitations which need to be borne in mind. Questions on bus travel were only asked of people aged 16 or over so estimates for the whole population cannot be made directly. Because physical difficulties with using buses are complex and a wide variety of tasks are involved, solutions to these problems are also complex; estimates of the number of people who might benefit from particular kinds of solutions can only be made in very broad terms from the survey – it is not possible to identify the market for particular kinds of adapted vehicle, for example. In addition, some solutions suit people with one type of disability but not others. The estimates are based on a description of problems experienced with the type of public transport which is currently available – which for most people still means the conventional, unmodified, bus; it is not necessarily true therefore that if present problems are overcome, elderly and disabled people will be able to use buses in the same way as other people – other problems may emerge. The demand for travel implied by the survey can only be estimated in general terms because the only travel data collected was frequency of bus use (in approximate number of days on which buses were used) during the last 6 months; some indication of travel demand is gained by reference to other surveys.

3. THE DEMAND FOR SPECIAL TRANSPORT

3.1 Problems with bus travel

Ten per cent of respondents in the GHS reported experiencing a health problem that made bus use difficult for them. Table 3 shows that difficulty getting on and off was the most common problem, followed by getting to the bus stop; waiting at the bus stop, moving to and from seats and travel sickness were less common.

For some people, these problems did not appear to affect bus use (as Section 4 will show), but others travelled less frequently by bus if they had difficulty and some respondents reported that they did not use buses because of this physical difficulty; in some cases, this was the only reason for not using buses, but in others, factors such as having a car available also played a part (see Table 4).

Three-fifths of people reporting physical difficulties with bus use were over the age of 65, and three-quarters reported a limiting long-standing illness or disability, but some of those with difficulties were neither old or suffering from limiting illness or disability, as Table 5 shows. Figure 1 shows that the proportion of people reporting physical difficulties increased dramatically with age. Three-fifths of those with such difficulties lived in households without a car (see Table 6); in all age groups, people with difficulty were less likely to live in car-owning households, and were therefore more dependent on public transport for journeys beyond walking distance, than were people without physical difficulty using buses. Most people with such difficulty were economically inactive: only 17 per cent were working (see Table 7), so the large majority would probably not have been able to afford to pay for taxis to avoid difficulties of bus travel; people with difficulty using buses were less likely to be working than those of similar ages without difficulty. A third of those with difficulty were living alone, and would therefore have had to travel to take part in day-to-day activities.

In addition to these difficulties with bus use associated with health problems, other problems were also mentioned. The main difficulty was that bus services were unsuitable, as Table 8 shows; this difficulty was more likely to be reported by non bus users (for whom it was reported as a reason for not using buses), than by bus users. The expense of bus travel was the other main problem;

among bus users this was about twice as likely to be mentioned by people under pensionable age as by older people, presumably because concessionary fares are provided for many people over pensionable age.

3.2 The general market for improvements in public transport

The people who might reasonably be expected to benefit from improvements to bus design and operation aimed at assisting elderly and disabled people are bus users* experiencing physical difficulty using buses, and non-users for whom physical difficulty is the only reason for not using buses. These two groups together amounted to 8.3 per cent of the people over 16 in the GHS, and included 30 per cent of those with a limiting long-standing illness or disability. Thus 8.3 per cent of the population over 16 (or 3.5 million people in Great Britain) would be likely to benefit directly if it were possible to make enough improvements to bus services of the kind described earlier to overcome all the problems experienced by elderly and disabled people. It would be rather optimistic to expect that people with physical difficulty who also had other reasons for not using buses would begin to use buses (or alternatives to conventional bus services) if these improvements were made, but if people with physical difficulty and reasons other than not needing to use buses could be attracted onto buses, the proportion of people benefitting would increase to 8.6 per cent. Other people, such as those who have difficulty coping with their children and shopping when travelling by bus, would probably also benefit to some extent.

Table 9 shows some of the characteristics of the people in the GHS who constituted the main market for improvements in public transport for elderly and disabled people. More than two-thirds of them were women, a third were over 75, and a third lived alone and half were elderly people in non car-owning households; half were elderly and suffering from a limiting long-standing illness or disability, while a quarter were younger people with such a disability. Almost three-quarters were bus users, and a third used buses on at least two days each week.

3.3 The market for particular types of transport improvement

It is likely that many of the people with more than one physical problem preventing them from using buses would be unable to use buses unless all of their problems could be overcome. The number of people who might benefit from individual types of improvement depends on the way in which problems combine for different groups of people. Table 10 shows estimates of the proportion of the sample who were members of the group defined as most likely to benefit and who reported various combinations of problems. From this, the market for different types of improvement can be estimated, although accurate figures are not yet available.

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* Bus users in the GHS were defined as those who had used local bus services in the last 6 months.

3.3.1 Modifications to conventional services. Table 10 suggests that the simplest single measure that would benefit the largest group of people without altering the nature of the service provided is improving the design of bus entrances and exits; 2 per cent of people over 16 would probably benefit and this could be increased to 2.6 per cent (or 1.1 million people over 16 in Great Britain) if in addition, people's problems moving around inside buses could be overcome. These people were rather older than those forming the general market for improved services shown in Table 9; 54 per cent were over the age of 70. The kind of improvements which are involved include lower steps, better placed and designed handrails and bell pushes, wider spaces between seats, reserved seats near bus entrances, improved ride characteristics providing helpers, and waiting until all elderly and disabled passengers are seated before driving off. The research on "split step" and "kneeling" buses in Sheffield (Oxley and Benwell, 1983) suggested that improving the design of bus entrances does make it easier to use buses, because people using the modified vehicles were more likely to report that they had problems moving around inside buses than to report problems getting on them, whereas Table 3 shows that problems boarding and alighting are three times more common among bus users, than problems moving around inside buses. Experimental work at Cranfield reported in another paper at this conference (Oxley, 1984a) has suggested various design improvements that would help this group of people, and suggested that bus operating times might increase by about 1 per cent if drivers waited until all disabled people were seated before moving off, and by rather less than 2 per cent if disabled passengers alighting also remained seated until the bus had stopped.

The other measure that could be implemented without changing the type of bus service provided or involving vast expense, is to provide seats and shelters at all bus stops. Table 10 suggests that this would assist 0.2 per cent of people over 16 who have difficulty waiting for buses and no other problem (including some who reported that physical difficulty prevented them from using buses); other bus passengers would also benefit. One study reported that 98 per cent of disabled bus users did not have a seat at their nearest stop (Morris and Gazely, 1977). The people reporting difficulty waiting at bus stops were more likely to be under 65 and suffering from limiting long-standing illness than those in other groups of potential beneficiaries of bus service improvements.

The three types of measure aimed at assisting elderly and disabled bus users on conventional services would probably meet the needs of about a third of all the people in the GHS identified as the potential market for such improvements. The fact that only about a sixth of them were not bus users suggests that modifications to conventional stage carriage services, rather than the provision of alternative services with more suitable vehicles, is likely to be the most cost-effective solution. For most of the remainder, however alternative types of service might be more appropriate.

3.3.2 Alternative services. For one of the remaining groups, those with difficulties on buses and reaching the bus stop, door-to-door services using special vehicles are the obvious solution. The fact that half of them were unable to use local buses, while those who could used them less often than people with other types of difficulty, substantiates the case for alternative types of service. There are two main types of service which could be provided: subsidised taxis, and door-to-door special bus services using adapted minibuses or cars. From the data available in the GHS it is not possible to estimate the market within this group for these two types of service, but from the point of view of the users, the way in which it is divided probably depends on two factors: the nature of people's disabilities, and their attitude to being treated as "special cases". Conventional cars and taxis are not yet wheelchair-accessible (although the next generation of taxis in the large towns of Great Britain will be), so special services with lift or ramp-equipped vehicles are the only alternative for the most severely disabled people in this group. Others benefit from the helpful, caring nature of the service provided by special transport schemes which they do not consider they would obtain from a taxi service (a survey of users of one special transport scheme showed that after cost, the main advantage of the service compared with taxis was that the staff were helpful and caring (Bowlby, Kirby and Swann, 1984)). On the other hand, some disabled people probably welcome being treated as much as possible like able-bodied people, and would therefore prefer a subsidised taxi scheme to any form of transport provided specially for disabled people. If cost-effectiveness were to be the only criterion used to determine whether people in this group should be provided with subsidised taxis or special services, all but those who were physically unable to use taxis would be provided with a subsidised taxi service; research on the operations of one scheme ('Readibus') included theoretical comparisons between these two types of provision and showed that for the same net cost, a subsidised taxi service can provide far more journeys for disabled people than a special transport scheme (Heraty, 1984). This research on Readibus also enables some estimates to be made of the way in which the market for alternative services might be divided if this criterion were used; the scheme was open to anyone who was unable to use public transport, and one-fifth of the users were in wheelchairs (Heraty, 1984). Since half of the people in the GHS with difficulties on buses and getting to the bus stop were bus users, they would almost certainly be able to use taxis. If the remaining half were like Readibus users, a tenth of the entire group (or 0.25 per cent of people aged 16 or over) would require special transport for people in wheelchairs, and the remainder (2.25 per cent of people over 16) would be able to use subsidised taxi services.

The people with difficulty reaching bus stops and on buses were older than those in the other groups, and less likely to be working; almost all suffered from a long-standing illness or disability. It is likely therefore that their travel requirements would be rather different from those of other groups.

The other group for whom some form of alternative to conventional public transport might be beneficial is the people with difficulty getting to the bus stop and no other problem, and those who also had difficulty waiting at bus stops; these comprised 1.2 per cent of the population over 16 in the GHS. For these people, three types of solution are possible, although one is probably impractical. Feeder bus services taking disabled people from their homes to the main bus network are one solution. The advantage to the users is that they can wait at home or in the feeder bus, rather than at the bus stop, and the amount of walking is reduced. For the operator, the amount of mileage without any passengers on board is likely to be lower than on special services, while patronage on the main network would probably be increased because about a third of the people in this group were not bus users, due to the difficulties they experienced in reaching bus stops. Another alternative would be to provide denser networks of conventional bus services, presumably at reduced frequency. This would involve disbenefits to other users, although it is likely that some other passengers would benefit from the decrease in walking distances. Evidence from the British National

Travel Survey suggests that shorter distances to bus stops are associated with more frequent use of buses at all levels of service frequency, both among the whole population and the elderly. However research on service elasticities suggests that in the population as a whole, frequency of bus travel is more sensitive to differences in frequency of service than to differences in route density (TRRL, 1980); there is no evidence to suggest whether this is the case for elderly and disabled people, but the reverse could well be true. It is likely therefore that denser route networks with less frequent bus services would be associated with a decrease in bus patronage and net disbenefits to other passengers. The third solution for this group is to include them in the group qualifying for special transport or subsidised taxes. Such transport is more difficult to justify in this case, since only one-third were prevented from using buses by this problem (compared to half of the people in the other group). The decision on whether to provide feeder buses or special services for this group would probably depend on whether local policy favoured providing a variety of different transport schemes meeting disabled people's needs as cost-effectively as possible, or fewer types of scheme for organisational simplicity, accepting that some people were not being provided with the cheapest possible service to suit their disability.

3.4 Future changes

The population structure of the UK is changing, and over the next 20 years or so there will be an increase in the number of very old people; between 1981 and 2001, the population over 75 will increase by an eighth (Central Statistical Office, 1983). If the rates of incidence of difficulties with bus travel remained the same in each age and sex group between 1982 and 2001, this change in population structure would mean an increase of 3.9 per cent in the number of people over 16 with difficulty using buses, and of 4.4 per cent in the number over 65 with such difficulty. Although this indicates that the problem is likely to increase in scale to a small extent if improvements to bus services to suit the needs of disabled people are not implemented over the country as a whole, this figure cannot be used as a basis for estimating the size of the future population of people with difficulties because it takes no account of any change in the nature of the bus service provided over the next 20 years. Such changes could be dramatic after the introduction of the proposed legislation for deregulation of the bus industry, and it is not yet clear what effect the operation of the free market is likely to have on the provision of special services or the improvement of vehicle design to accommodate the needs of elderly and disabled people. Similarly, it is not clear what effect deregulation will have on the decline in level of bus service provision, but changes in levels of service could have substantial effects on the proportion of people with difficulty using buses.

4. TRAVEL DEMAND

It has already been noted that 18 per cent of bus journeys in Great Britain are made by people over pensionable age, and by applying rates of reporting difficulties with bus travel among bus users in the GHS to National Travel Survey data, it can be estimated that 9 per cent of all bus journeys are made by people with difficulty using buses. The potential demand for travel on buses or alternatives to conventional public transport is difficult to estimate because evidence on current levels of travel is very fragmented, and the extent of unmet demand for new services among a group of people who have generally become accustomed to a very low level of mobility, is almost impossible to assess. This section will briefly review the available evidence on the use made of special transport services and conventional bus services by disabled people, to provide some indications of the minimum level of demand for such transport.

4.1 Effects of difficulties on frequency of bus travel

The number of bus users in the GHS was clearly affected by health difficulties, since 2 per cent of all respondents reported that the only reason why they did not use buses was the physical difficulty involved. Among bus users in general, frequency of bus use appeared to be slightly affected by health difficulties but elderly bus users travelled rather less frequently by bus if they had difficulties than if they did not, while younger people used buses more often if they had difficulty (see Table 11). A possible explanation for this difference is that because the majority of people with difficulty using buses had a limiting long-standing illness or disability, they probably also had difficulty using other modes of transport and for younger people this may have meant travelling more by bus rather than using other more difficult modes, whereas elderly people may have avoided travelling rather than face the problems of bus travel.

One way to assess the scale of the effect of physical difficulties on frequency of bus use is to estimate the number of extra bus journeys which might be made if all such difficulties could be overcome. Because health difficulty among bus users as a whole was not associated with a marked decrease in frequency of bus travel, most of the increase would probably occur as non-users whose sole reason for not using buses was the physical difficulty involved, began to use buses. If people with difficulty could travel by bus as often as others of the same age and sex, bus journeys would probably increase by around 4 or 5 per cent.

Some combinations of difficulties appear to have had a greater effect on frequency of bus travel than others. It has already been noted that the proportion of bus users in the potential market for different types of improvement in service varied, and among bus users, there was also some variation. Table 12 shows that people with difficulty getting to bus stops (whether or not they had other difficulties) were less frequent bus users than those with other difficulties, while the three groups forming the market for modifications to conventional services did not use buses much less often than those without difficulty shown in Table 11 (except that the latter group were more likely to use buses on 5 or more days a week, presumably because a larger proportion were working). It is therefore likely that modifications to conventional services would be associated with a small increase in bus travel. People provided with alternative special transport could potentially increase their frequency of travel to a much greater extent, although their use of conventional services would probably decrease. (A survey of users of one special transport scheme found that many of the journeys had previously been made by bus but many had not previously been made at all (Bowlby, Kirby and Swann, 1984).

4.2 Use of special transport schemes

Research for TRRL on the use of special transport schemes is in progress at the Transport Studies Unit, Oxford University at the moment. Preliminary results and studies in other areas suggest that the average number of journeys per member is of the order of 0.75 to 2 journeys per month on two demand-responsive services with adapted vehicles (Islington dial-a-ride and Readibus), and two user-side subsidy schemes based on taxis (Southwark and Edinburgh Cripple Aid Society) (Bailey and Appleby, 1983; Heraty and Fowler, 1982; Foulkes and Howard, 1983). A longer-established user-side subsidy scheme in Stockholm, in which the number of journeys users could make on the taxis was restricted to 72 per year (although they could apply for more), passengers made an average of 5–6 journeys per month (Rihani, 1982); in 1976 it was reported that about half the permitted maximum number of trips were made, on average (Morris, 1976).

It is difficult to assess the potential demand from these figures because dial-a-ride services tend to be constrained in the capacity they can provide, while the costs involved in paying the passenger's contribution to taxi fares on a user-side subsidy scheme may also constrain demand in this low income group. Some idea of the level of unmet requests for journeys can be obtained from the survey of Readibus where a third of users reported journeys that they had been unable to make on the service (Bowlby, Kirby and Swann, 1984).

Use by individual members appears to be extremely variable; for example on Readibus, 25 per cent of the journeys were made by only 8 per cent of the passengers. For some users, Readibus quickly became their main means of transport whereas for others it was used occasionally, sometimes as a back-up when other means were not available (Bowlby, Kirby and Swann, 1984). Although average use may be low, because disabled people generally have a low level of mobility, journeys on special transport can still comprise a large proportion of their journeys; for example a third of all journeys by Readibus users in the previous week had been made on the Readibus service (Bowlby, Kirby and Swann, 1984).

Rapid growth in the number of journeys made on special and modified transport has been observed in most schemes, at least in the first few years (see for example Bailey and Appleby, 1983; Bowlby, Kirby and Swann, 1984; Oxley, 1984b).However evidence from two special schemes (Readibus and Edinburgh Cripple Aid Society) suggests that the number of users increases at the same rate, so the number of journeys made by each user does not increase. Given sufficient time and an unconstrained capacity in the service, use would probably increase substantially; it is however unlikely in the short term to increase to the frequency of travel by able-bodied people, because many disabled people are elderly, they tend to have low expectations, and to have adapted their style of life to suit a very low level of mobility.

The implication of this is that in the short-term at least, it should be possible to predict the approximate level of use that will be made of any given special or modified transport scheme in Great Britain (even if it is not possible to predict the potential demand). The incidence of transport disabilities among the population in the local area (which can be estimated from age-specific rates of reporting difficulties in the GHS), combined with the data on the use of other similar transport schemes already in operation which is now becoming available,will probably provide a reasonable basis for making such estimates.

5. SUMMARY AND CONCLUSIONS

Travelling by bus involves a number of physically demanding tasks which represent considerable barriers to disabled people, but such people form a significant portion of the market for bus travel. Ten per cent of people over 16 in Great Britain experience physical difficulties using buses, and 8.3 per cent have been identified as forming the main market for improvements in public transport to suit elderly and handicapped people, because they are bus users or people whose only reason for not using buses is the physical difficulty involved. People with difficulty using buses are more likely to suffer from other disadvantages affecting travel; for example they have lower levels of car ownership and economic activity than people of the same age without difficulty using buses.

Preliminary analysis suggests that for a third of these people, these problems could be overcome if modifications to the design of conventional buses of the type that are now being made in some areas became widespread, improving entry and exit designs and making it easier for disabled people to move around inside buses. For another third with difficulty reaching bus stops and on buses, special door-to-door services are probably the most cost-effective solution since half are unable to use local bus services and the remainder appear to use them less frequently because of the difficulties involved. The requirements of this group are also likely to differ, since almost all had some long-standing illness or disability. Within this group, a small minority would require special transport for people in wheelchairs but other door-to-door services would be adequate for the majority. The remaining people,with difficulties reaching bus stops but no difficulties on the vehicles, could be provided with feeder bus services or special door-to-door services.

A wide variety of forms of special transport is now available in Great Britain, and evidence on the most cost-effective types of provision which best meet people's travel requirements is now being collected. However financial constraints may mean that it will not be possible to continue subsidising the whole range of different types of scheme, and decisions will have to be made on the best balance between different types of service. The evidence on the size of the market for different types of transport suggests that a combination of modified conventional services, subsidised taxi services and special vehicles providing a door-to-door service for people who cannot use taxis or modified conventional services will be the most cost-effective solution, based on conventional transport used by able-bodied people which is accessible to over half of the people forming the main market for special services. This ignores the question of the most satisfactory balance of service for meeting people's travel requirements, but it is hoped that this will be answered by research now in progress.

This paper has shown that although demand for travel on these schemes is at present difficult to estimate, the use made of them by individual disabled people is very low and at least in the short term, does not appear to increase very much as people adapt their travel patterns to the new opportunities available; growth in use appears to occur as the number of users of schemes increases. Thus in the short-term, travel demand can be predicted on the basis of the size of the market and use of existing schemes, which appears to be at a rate of 1–2 journeys per month on average. In the long term, however, as expectations rise and new generations of disabled people enter the market, travel demand by disabled people must surely increase as it has in Sweden; the size of the market may also change as the nature and level of bus service provision changes following deregulation, although the likely effect is at present difficult to predict.

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TABLE 1

Difficulties with buses reported by disabled bus users in Coventry

Difficulty	Weighted %* of bus users
Getting on and off	
Bus parking too far from kerbs	65
Step height	61
Handling bags	53
Other passengers	13
Handrails	9
Platform width	1
On buses	
Bus moving off before seated	83
Moving to let others in/out	24
Leg room	20
Signalling for next stop	13
Handrails	11
Storage of bags	8
Seat height	7
Paying driver	5
Number of bus users	92

* Weighted to correct for differences between impairment of sample and population estimates.

Source: Morris and Gazeley, 1979.

TABLE 2

Difficulties with buses reported by elderly and disabled people

Difficulty	Disabled %	Elderly %	Lame/elderly %
Number of bus steps	44	19	43
Height of bus steps	87	78	93
Depth of bus steps	34	27	27
Width of bus entrance	15	11	10
Handrails at entrance	35	14	17
Handholds inside the bus	40	30	27
Getting into bus seats	62	27	33
Comfort of bus seats	29	46	23
Getting out of bus seats	59	32	50
Number of Subjects	116	37	30

Source: Brooks, Ruffell-Smith and Ward, 1974.

TABLE 3

Proportion of people aged 16+ with physical difficulty using buses

Difficulty	Bus user*	Non-user			Total
		Physical difficulty only reason	Physical difficulty and other reasons	Other reasons	
	%	%	%	%	%
Getting on or off the bus	6	74	62	1	6
Getting to or from the seat	2	51	32	1	3
Getting to the bus stop	3	66	54	2	4
Waiting at the bus stop	2	50	39	1	3
Travel sickness	1	9	14	1	1
Other	2	10	12	1	2
Number of respondents	12264	444	188	6783	19679

* Bus users were people who had used local buses in the last 6 months.

Source: 1982 GHS

TABLE 4

Bus use and physical difficulty using buses: people aged 16+

Percentage of respondents

Frequency of bus use	Health difficulty with buses		Total
	Yes	No	
5+ days a week	0.9	12.0	12.9
2–4 days a week	1.9	13.1	15.0
1 day a week	1.1	9.0	10.1
1–2 days a month	0.9	8.7	9.7
Less often but in last 6 months	1.3	13.3	14.6
Not used in last 6 months			
– health difficulty only reason	2.2	–	2.2
– health difficulty and use car/no need	0.7	–	0.7
– health difficulty and other reason	0.2	–	0.2
– other reasons only	1.3	33.1	34.4
– housebound	0.3	–	0.3
Total	10.9	89.1	100

Source: 1982 GHS

n = 19734

TABLE 5

People with physical difficulty using buses: age and health

Percentage of respondents

Age	Limiting long-standing illness or disability		Total
	Yes	No	
16–44	8	6	14
45–64	23	5	28
65–74	23	4	27
75+	24	7	31
All aged 16+	77	23	100

Source: 1982 GHS

n = 2075

TABLE 6

People with physical difficulty using buses: age and household car ownership

Percentage of respondents

Age	Number of household cars 0	1	2+	Total
16–44	5	7	2	14
45–64	13	11	4	28
65–74	18	8	1	27
75+	25	5	1	31
All aged 16+	61	31	8	100

Source: 1982 GHS

n = 2088

TABLE 7

People with physical difficulty using buses: age and working status

Percentage of respondents

Age	Working	Not working	Total
16–29	3	3	5
30–44	4	5	9
45–64	8	20	28
65+	1	57	58
All aged 16+	17	83	100

Source: 1982 GHS

n = 2089

TABLE 8

Proportion of people aged 16+ with other difficulties using buses

Difficulty	Bus user %	Non-user %	Total %
Bus service unsuitable	15	22	18
Expense of bus travel	11	11	11
Coping with children	3	1	2
Coping with shopping	2	*	1
Other	3	1	2
Number of respondents	12271	7579	19850

*Less than 0.5 per cent

Source: 1982 GHS

TABLE 9

Characteristics of people who would benefit from public transport improvements

Percentage of respondents

a) Age and car ownership

	No household car	Household with car	Total
16–19	0.8	0.8	1.6
20–29	1.5	1.9	3.4
30–44	3.7	4.2	7.9
45–59	8.1	7.4	15.5
60–64	7.8	3.4	11.2
65–69	9.2	4.0	13.2
70–74	12.1	3.1	15.3
75–79	13.6	2.1	15.6
80–84	9.1	1.0	10.1
85+	5.3	0.8	6.2
Total	71.2	28.8	100

n = 1657

b) Age and limiting long-standing illness or disability

	With limiting illness	No limiting illness	
16–29	2.0	3.1	
30–44	5.4	2.5	
45–64	21.5	4.9	
65–69	10.9	2.2	
70–74	12.7	2.6	
75–79	12.4	3.1	
80+	12.6	3.6	
Total	77.4	22.6	n = 1657

c) Age and household type

	Alone	Elderly people only	Other
16–29	0.2		4.8
30–44	0.4		7.5
45–64	5.2		21.5
65–74	10.6	11.3	6.6
75+	17.7	9.4	4.7
Total	34.2	20.7	45.1

n = 1657

d) Age and working status

	Full time	Part time	Unemployed	Other
16–64	8.2	4.6	2.3	24.7
65+	0.2	1.0	0.1	59.0
Total	8.4	5.6	2.4	83.7

n = 1655

Source: 1982 GHS

TABLE 10

Estimated proportion of people with various combinations of difficulties with bus use

Difficulties with bus use	Bus user %	Non-user, physical difficulty sole reason %	Total %
1. Getting on or off the bus only	2.8	0.9	2.0
2. Getting to or from the seat only or getting to or from the seat and getting on and off the bus	0.8	0.4	0.6
3. Waiting at the bus stop only	0.3	0.1	0.2
4. Getting to the bus stop only or getting to the bus stop and waiting	1.3	1.0	1.2
5. On-vehicle and bus stop	2.0	3.2	2.5
6. Other	2.7	0.4	1.8
Number of respondents	12280	7580	19860

Source: 1982 GHS

TABLE 11

Frequency of bus travel, age and physical difficulty

Percentage of bus users

	Age and health difficulty								All ages	
	16–29		30–64		65–74		75+			
	Difficulty	None	Difficulty	None	Difficulty	None	Difficulty	None	Difficulty	None
5+ days a week	34	28	18	19	13	15	7	14	15	21
1–4 days a week	28	35	43	36	53	56	58	55	48	39
Once or twice a month	19	16	15	16	15	14	16	16	16	16
Less often, but in last 6 months	19	20	24	29	19	14	20	15	21	24
Number of respondents	79	3514	481	5598	349	1367	290	586	1199	11065

Source: 1982 GHS

TABLE 12

Frequency of bus use among estimated market for various improvements in bus service

Difficulties with bus use	Bus users — per cent using buses				% who were non-users (estimate)	Number of respondents (estimate)
	5+ days a week	1–4 days a week	Once or twice a month	Less often, but in last 6 months		
1. Getting on or off the bus only	15	54	15	15	16	407
2. Getting to or from the seat only or getting to or from the seat and getting on or off the bus	18	55	10	18	22	122
3. Waiting at the bus stop only	14	51	11	24	18	45
4. Getting to the bus stop only or getting to the bus stop and waiting	12	50	20	19	32	232
5. On-vehicle and bus stop	11	48	16	25	50	486

Source: 1982 GHS

DEVELOPMENT OF AN EVALUATION METHODOLOGY FOR ELDERLY AND DISABLED TRANSPORTATION PROGRAMS: A COORDINATED APPROACH

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INTRODUCTION

Government agencies that fund elderly and disabled transportation programs are required to be accountable for the funds they allocate. There are a number of ways that these agencies can demonstrate accountability but it is usually determined by fiscal and/or program evaluations/reviews. This, in turn, depends on the information generated by the transportation provider.

The monitoring and evaluation of elderly and disabled transportation programs by funding agencies is critical to their accountability requirements. Typically, when funding agencies design and perform evaluations, they have only their own needs in mind.

Funding agencies often require considerably more information of these providers than is needed to perform an evaluation or audit. This results in higher administrative costs for providers and funding agencies. A coordinated evaluation will change this and may be the best way to get funding agencies more involved in improving the overall service, not just for their clients. It will enable funding agencies to assess their own collective administration of the provider, correct deficiencies and resolve conflicts between each other. In Texas this is something that the transportation providers are doing, rather than the funding agencies.

This paper contends that any plan for funding agency coordination should start with an evaluation. Problems cannot be corrected until they are recognized and understood by all concerned. A coordinated evaluation can accomplish this and pave the way for expanded administrative coordination.

This paper will discuss accountability and what is needed. Next it will focus on the role of government in accountability and what is required by each funding agency. The paper will close with a discussion on the development of a coordinated approach toward the evaluation of elderly and disabled transportation services.

ACCOUNTABILITY

Typically, elderly and disabled transportation as well as rural public transportation systems (when they have multiple funding sources) in Central Texas have to comply with up to four different sets of recordkeeping and accountability requirements. Compounding the problem of multiple recordkeeping and accountability requirements is the level and amount of information sought by various funding agencies. Some agencies insist on information and documentation of rural public systems that is far in excess of what any other form of public transport is required to report. Rural public transportation systems must often verify client eligibility and that clients are going to an eligible service. Such verification can require several telephone calls, often long distance, placing a burden on the rural public transportation system.

What is accountability? At what point are the reporting requirements of funding agencies a legitimate need and at what point are they a waste of time and money? Besides the waste of time and money, the more information a funding agency requires, the greater chance that providers may view all data requirements as superfluous, thus minimizing the importance of it and reducing the accuracy of the data collected and reported. In other words, they make it up.[1] This would make any attempt at accountability unreliable without it being obvious. In this context accountability is the demonstration of proper use of funds given by one agency to another for the purpose of providing a service. Is the service provided at a reasonable cost and are the funds being spent as required?

The recordkeeping and accountability functions required by funding agencies revolve around three basis needs. These needs are:

1. Program Accountability. The procedures used to verify that the service was provided and that it was delivered to an eligible individual. This could be anything from reporting just the number of trips taken by elderly persons to the reporting of names, destination and trip purpose for each trip.

2. Cost Allocation. Funding agencies need to make sure that they are not receiving a service that is more expensive than they could receive elsewhere.

3. Service Accountability. Some funding agencies need to evaluate the quality of the service provided to make sure services were delivered as specified in the contract or grant.

Transportation providers, on the other hand, are generally not interested in individual client groups; rather, they want an evaluation that reveals efficiency of the system. The general feeling among providers in Central Texas is that, if they can improve the overall service, then, service to individuals will improve. Human service agency fundors are interested in their own clients usability of the system. An Office of Human Development Services publication states the difference very well. "The essential difference between public transit and social service transportation is the concern with an individual's trip."[2]

GOVERNMENT'S ROLE

President Reagan's administration has brought a new focus to Federal involvement in transportation. In elderly and disabled transportation services, as well as rural public transportation, the state and local entities have almost full control. Clearly it is up to the states to seize the moment and develop policy and procedures that will be effective.

There are a number of approaches that a state can take, which fall into three categories. They are:

1. Fragmented. This is a state where there are no formal (but may be informal) cooperative/coordination agreements. Each state agency runs its own program separately from other agencies. Texas is an example of this approach.

2. Cooperative. This approach is found in states where there is a formal working agreement among the agencies involved to coordinate services. This is usually developed through a nonbinding interagency agreement. Massachusetts and Arkansas are typical examples of this type of approach.

3. Coordinated. In states where there is enabling legislation or an executive order mandating coordination, services are typically coordinated through a local council of agencies with one state agency serving as lead. Examples of this approach are South Carolina and Michigan.[3]

Any of the three approaches can produce coordination between state agencies. It does appear that the cooperative and coordinated approaches may better lend themselves to agreement. This paper will not, however, recommend one framework over the other. The important thing is to talk and communicate.

THE NEED FOR A COORDINATED APPROACH

A coordinated evaluation methodology takes a committment to team work. It can produce the following benefits:

1. A more intensive and complete evaluation.

2. Less time and money expended by funding agencies and transportation providers on evaluation (administration).

3. A streamlined recordkeeping process.

4. Less of an imposition on the transportation provider (not three to six sets of evaluations).

5. A document that the provider can use as a tool to improve the service.

6. A corrective action plan agreed upon by all interested groups.

7. The possibility that this could lead to other cooperative efforts.

There are five major transportation programs that fund transportation for the elderly and disabled in Texas. Three state agencies administer the programs and two Federal departments (DOT and HHS) oversee them. The five programs each have a large degree of state and local control. Following is a description of the evaluation requirements of the five programs at each level of government.

1. Section 16(b)2 of the Urban Mass Transportation Act. This program funds capital acquisitions. The Section 16(b)2 Capital Assistance Program Guidance Circular states that:

> ...the State agency is expected to certify eligibility of applicants and project activities, review applications, select projects for approval, ensure compliance with Federal requirements, monitor local projects and oversee project audit and closeout. [4]

There are no specific monitoring and evaluation guidelines from the federal level.

The Texas State Department of Highways and Public Transportation

(SDHPT) administers the Section 16(b)2 program in Texas. Since Section 16(b)2 is a capital acquisition program there is very little monitoring and evaluation performed. There are no specific evaluation procedures from the state level. The district office, of which there are 25 in the state, perform the monitoring and evaluation functions. These consist of monitoring monthly reports for utilization by the appropriate client groups (elderly or disabled), routine maintenance and insurance. The district contact person also makes at least one field visit per year.

2. Section 18 of the Urban Mass Transportation Act. UMTA has basically the same policy regarding the evaluation and monitoring of Section 18 as of Section 16(b)2: little or no involvement in day to day administration of the programs. The states are to be responsible and certify that the projects are meeting the statutory and administrative requirements for project approval.

The SDHPT administers this program. There are no written procedures at the state level for evaluating Section 18. The District office is responsible for monitoring and evaluation. This consists of monitoring reports and looking into any problems revealed through the monitoring. The district contact person makes a field visit yearly to inspect equipment. In addition audit staff of SDHPT perform yearly fiscal audits.

3. Title XIX of the Social Security Act. Title XIX provides funds for medical transportation of Medicaid recipients. The Department of Health and Human Services administers the program at the Federal level. There are no specific evaluation and monitoring requirements other than of a very general nature.

The Texas Department of Human Resources (TDHR) administers the Title XIX Medical Transportation Program in Texas. In almost all areas of the state services are contracted out to various public and private transportation providers. The state office determines policy and ten regions each administer their own program. State office has developed evaluation standards for providers called service control standards (SCS). These standards revolve around verification of client eligibility, denial of trip, on time performance and changing of scheduled departure time. Its intent is to:

> ...reveal the quality of contracted transportation services for eligible clients to medical services and divulge the quantity of contracted transportation services received by ineligible individuals. [5]

The main evaluation tools are trip logs and telephone surveys of clients and medical providers. Included in the contract review (evaluation) in addition to the SCS, is a check on the number of staff and equipment as well as compliance with insurance, intake and trip log requirements.

At the regional level, Region 6 admisters the program in 30 counties of Central Texas, an area of 26,000 square miles. In addition to the state mandated evaluation, the region collects data on courtesy, comfort and two needs assessment questions while conducting the client survey. Field workers are surveyed by mail, with follow up telephone calls when necessary. Spot inspections of provider vehicles and drivers are also included in the evaluation.

It is interesting to note that if TDHR chose to use administrative funds at a slightly lower match it would not be required to keep records on each client.

4. Title XX of the Social Security Act. Title XX is a federal block grant with no specific evaluation requirements for transportation from the federal level. In Texas transportation is not a direct service. At times it is built into an individual contract as a support service. As a result of this, there are no evaluation requirements targeted for transportation. The contract evaluation simply notes that transportation is being provided. Due to the fragmented nature of transportation in the Texas Title XX program, very few coordinated transportation systems utilize Title XX funds.

5. Title III of the Older Americans Act. The Administration on Aging in the Department of Health and Human Services administers the Title III Nutrition Services and Area Planning and Social Services Program. There are no specific evaluation requirements for transportation other than the state being accountable for monitoring the program. The Texas Department on Aging (TDOA) also has no specific requirements for evaluating transportation.

The local area agencies on aging (AAA) administer the funds at the local level. It is here that specific evaluation requirements are developed. One AAA in Central Texas performs an extensive evaluation. This includes field observation (talking to users and examining equipment) as well as a full examination of records (logs, financial statements and contribution lists). Other contract requirements are monitored as well. Another AAA performs field visits and does a cursory review of records without getting into details. A yearly public hearing is held so that board members can determine where to allocate funds. A third agency does nothing more than field visits. As can be seen, evaluation of Title III transportation is up to each local AAA.

DEVELOPING A COORDINATED APPROACH

The preceding section demonstrates that each agency performs its own evaluation in its own style, oblivious to each other and, for the most part, each funding agency is doing things differently. As stated earlier, the Social Service agency fundors are more concerned with an individual trip. Public transit is more interested in vehicles being on the road, on schedule and well maintained with skilled drivers. These are natural dividing lines which clearly lend themselves to a coordinated evaluation. This should be kept in mind when developing an evaluation plan.

In developing a coordinated evaluation methodology, the first step is to open a dialogue between the various funding agencies at the state and local level and the transportation providers. After all, these entities are in business together and it is in everyone's best interest to talk. The purpose of this is to look at how to coordinate state and local administrative and operational functions. One component of this administrative coordination is the evaluation.

Once the agencies and providers meet they can begin to compile their collective goals and procedures into a workable evaluation plan. This plan consists of three components: 1) formation of criteria, 2) assessment of attainment of criteria, and 3) utilization of results. These three components are described below.

1. Formation of Criteria. The transportation provider must be evaluated based on some set of criteria or standards. The standards can be based on the outputs of its own program over time, to similar systems or to standards set by funding agencies. All three have problems inherent in them.

Taken together, though, a balance can be achieved. For example, the agency that uses standards based on past performance may be looking at very low standards, so an above standard rating may still be low, compared to similar systems. When developing standards, if similar systems are looked at, the agency will know if its standards are too low. Funding agencies should also look at their own program over time and similar programs in order to develop realistic standards.

Initially, funding agencies have to determine what is important enough to be measured. After this has been determined, the development of a standard and a method of measurement is required. Not all standards will be easily measurable though, as Rosenbloom points out:

> ...Everyone wants clean vehicles, helpful drivers and safe operations. But you must decide how these service factors will be measured and you must set minimum levels of acceptable service; vehicles can't always be clean and accidents happen occasionally. How clean is clean? How safe is safe?[6]

Many times these sorts of subjective standards can only be measured in general terms. Just because they cannot be quantified, doesn't mean they are not important. Subjective standards do have merit as long as they are measured consistently throughout a program. For Section 16(b)2 and Section 18 grants, vehicle and system productivity standards are looked at closely. Productivity measures (passengers per vehicle mile, load factors and vehicle hours per vehicle) are useful and measurable. Subjective standards, (vehicle cleanliness, driver courtesy, and on-time performance), rather than the productivity standards, are what human service transportation programs such as Title III and Title XIX, are interested in. This again gets back to the interest in the individual trip.

These two sets of programs seem to complement each other in terms of a well rounded evaluation. The human service fundors will be able to compare their program in relation to the overall efficiency of the system. The fundors of the public transit component will be able to see if service is provided equitably; that is, looking beyond the numbers to the actual quality of the service. This allows both types of agencies added perspective with little additional work.

It is at this point that funding agencies must realize that, in evaluating the overall program, they are evaluating themselves and how their collective administration is affecting the program. Therefore, funding agencies must develop standards to measure their own performance separately and collectively. For example, are the recordkeeping requirements duplicative or excessive or, are two funding agencies requesting conflicting services?

2. Assessment of Attainment. This step requires the use of monitoring and inquiry to determine how well the criteria have been met. Once the standards to be utilized are established the next step is to determine the method of data collection required to measure the standards. For elderly and disabled transportation data can be collected by funding agencies through four means: a) field observation, b) surveys, c) public hearings, and d) examination of records. These are described in detail as follows:

a. Field observation. Field observation includes inspections of provider facilities' personnel and equipment, both on a formal and informal (spot inspection) basis. This form of monitoring is essential for evaluating service accountability. Field observation enables one to monitor the service accountability needs of funding agencies that cannot be monitored through reports. There is no substitute for field observation. At least twice a year an inspection of equipment and facilities should be made. A coordinated approach would enable funding agencies to coordinate and minimize the number of visits. Through field observation one can determine if the equipment condition complies with the contract or grant. For example, all funding agencies want to make sure the items spelled out in their contract are working as specified. Items such as functioning two-way radios, air conditioners and heaters can be checked only through field observation. Through surprise inspections one can observe the driving habits of the vehicle operator or check to see if they are assisting passengers (if it is called for in the contract). A check of the telephone access system can also be performed under field observation. A system that cannot be accessed adequately may be discriminating against certain clientel. The advantage in this coordinated evaluation is that only one agency needs to do this. Information is to be shared with other funding agencies.

b. Surveys. There are service accountability needs that cannot be monitored through field visits. Accountability needs of human service fundors include checking the on-time performance of the system as well as driver and intake courtesy. Public transportation fundors are interested in user attitudes and habits. These are needs that can be monitored through the use of surveys.

Surveys can be performed of users, case workers (or human service agencies) and/or advocates of particular client groups. Client surveys do, however, have a number of flaws limiting their credibility except in support of other data: they can be extremely costly to perform. Telephone surveys produce extensive long distance charges if the provider is multi-county and for a human service agency's poorest clients there usually is no telephone, resulting in the omission of an entire group of individuals. Mail-out surveys also involve a cost factor (the mail-out and return) and traditionally have a low rate of return. Caseworkers are often asked by clients to complete the survey.

Other inherent dangers in utilizing client surveys include accuracy of client response due to a desire to give the "right" information, fear of losing service if negative responses are received and poor memory of elderly persons. Useful information can be gathered in a survey if it is carefully designed. It is recommended that client surveys not be used alone as an evaluation tool due to the flaws. However, when combined with other data collection methods they can be very helpful in identifying problems. With the collective resources of multiple funding agencies it is possible to develop a quality survey instrument.

c. Public Hearings. Public hearings can be used in a way similar to surveys; to solicit input on the quality of the program through the public. As in surveys, public hearings also have flaws. One difficulty with public hearings is that organizations wanting to make a point can bus in large numbers of persons to testify for that organization, while those with opposing viewpoints may not have transportation available and their voices are not heard in the process. In addition, dissatisfied users that depend on the service are not likely to testify openly against that service for fear of reprisals. As in surveys, data collected from public hearings must be taken with a "grain of salt". Although, when combined with other methods, hearings can be helpful.

d. Examination of Records. Another important component of monitoring is the examination of records. Public transit fundors can examine performance and productivity measures while human service agencies can examine client and trip purpose eligibility indicators (program accountability) and cost allocation needs. Service accountability functions, such as examining agency insurance and training records, would also be performed.

Financial audits are included in the examination of records. There have been some experiments in the single audit concept, where one audit is performed for a transportation provider's entire program. Since program staff have little control over audit staff, this kind of coordination would require a close working agreement among all state agencies involved.[7]

The natural dividing line of funding agency responsibility clearly becomes evident in the assessment phase. The human service agencies can perform surveys and public hearings as well as look at individual trips. The public transit fundor can do field observations, assess program productivity and look at the system-wide approach. The key is in dividing up assignments appropriately and maintaining adequate lines of communication.

3. Utilization of Results. While not intrinsic to the process of evaluation, unless a direct attempt is made to link evaluation data to the decision making process, the impact of the findings will be minimal and delayed. In other words, if one is to go through the time and effort to evaluate a program, one should use the results to correct deficiencies.

Wherever deficiencies are noted a corrective action plan should be developed. The plan in a coordinated setting should be put together by the various funding agencies and the transportation provider. Without consent from each entity the plan will be destined to fail. The key to this approach is to make sure that agencies are not working at cross purposes. This must be accomplished and clearly understood in the formation of criteria component.

RECORDKEEPING

A coordinated recordkeeping approach should be developed based on the results of the first evaluation. Although beyond the scope of this paper, recordkeeping will be briefly discussed.

While some agencies are attempting to get away from excessive paperwork others are still adding on new requirements. The major problem with additional paperwork is cost. Time and effort expended in recordkeeping is time and effort taken away from the provision of service. A good starting point for any state would be to look at the work completed by the Transportation Accounting Consortium, which has performed an extensive study of recordkeeping needs and approaches to meeting those needs.

SUMMARY

What can funding agencies do to improve transportation of the elderly and disabled? The first thing necessary is a pledge to work together. Transportation providers often complain of conflicting requirements in both operations and administration. This paper contends that a good way to initiate cooperation among funding agencies is to perform a coordinated evaluation of transportation services, thus leading to the collective recognition of deficiencies in the program.

The first component is to collectively decide on goals and the criteria used to evaluate the contractor. This gives all concerned a clear and concise picture of what is required of the transportation provider. The assessment phase will uncover where there is duplication, conflict or other problems that are the concern of funding agencies.

The utilization of results is critical. If nothing else, the evaluation should be able to assess and correct any deficiencies in funding agency administration. This leads back to the question, What can funding agencies do to improve transportation of the elderly and disabled? State agencies must get together and initiate a coordinating mechanism so that local (regional and district office) funding agencies can have the flexibility to make necessary changes while still being accountable. This is where a coordinated evaluation can help initiate the process. It is time to get providers out of the job of coordinating state agencies and back to just transporting people.

FOOTNOTES

1. In discussion with operators from Texas there were several indications that data was not adequately verified prior to reporting. Most of these operators had a human service orientation.

2. Office of Human Development Services, HDS Transportation Initiative: A report on Research Findings. 1981 pg. 22

3. The Transportation Accounting Consortium report Simplifying Human Service Transportation and Small Transit System Accounting. 1983, surveyed the accounting and reporting practices of member states. It gives excellent examples of the types of coordination approaches states can take.

4. Urban Mass Transportation Administration, Circular - Section 16(b) (2) Capital Assistance Program Guidance. 1983, pg 1 - 3.

5. Texas Department of Human Resources, Draft Medical Transportation Handbook, June 1984.

6. Rosenbloom, Sandra. How to Make Your Transportation System More Efficient and Effective . Urban Mass Transportation Administration. 1981, pg. 21.

7. The Transportation Accounting Consortium discusses the Single Audit concept extensively in its report.

THE PROCESS OF SUCCESSFUL TRANSPORTATION CONTRACTING: CASE STUDIES AND RECOMMENDATIONS

by

Mary Hough and Ann Zeltmann

Introduction

Cities and human service agencies have, over the past few years, tried many approaches to providing transportation for elderly, handicapped, and rural citizens, including attempts to contract with private transportation providers for service. Such contractual arrangements have oftentimes provided benefits for both parties. Agencies and cities, which have had neither the expertise nor the desire to be in the transportation business, have found they can achieve the same or better levels of service for less cost; have been able to retain some control over the availability of transportation service without the problem of running it; have found themselves in a more comfortable position working with, rather than competing with, private transportation providers; and in the case of agencies, once again have been able to concentrate their resources on their primary service. From the perspective of the private transportation provider, such contractual arrangements have removed what is viewed as unfair subsidized competition, and returned the responsibility for transportation service, along with the revenues, to those who have the ability to best provide the service.

Attempts by public entities to contract for transportation service in the private sector have produced widely varying results, with some notable successes and some disasters. Using a case-study method, our research examined the contractual processes used in four cities to provide public transportation through private providers. The purpose of the study was to determine what elements of the process produced success and what led to failure.

The case studies began with a survey conducted by the International Taxicab Association. The survey looked at programs in thirty cities where contracts between public transportation entities and either profit or not-for-profit transportation providers have been used. Most of the contract services surveyed provide transportation services for the elderly and handicapped. A few programs, however, offer transportation to the general public or rural transportation services. From the group of thirty, four programs were selected to be studied in depth. The selection of four allowed the opportunity to study the effects of a variety of elements on the contracting process: different program sizes; different city sizes; different political situations, different program designs; involvement of different types of transportation organizations. Most important, it allowed the opportunity to study programs which had achieved different degrees of success. The cities chosen were Lawrence, Massachusetts; Cleveland, Ohio; Hartford, Connecticut; and Portland, Oregon.

Of the four, the CRT program in Cleveland has operated relatively smoothly from original idea conception to current program implementation. The TRANSFARE program in Lawrence is also operating smoothly now, but a number of political problems had to be overcome in setting it up. In contrast, Hartford's Dial-A-Ride Program and Portland's LIFT program were, at the time of our research in the Fall of 1981, still struggling to work out difficulties.

The following case studies describe how each of the four programs had evolved and how they were being operated at the time our study was conducted.

Lawrence, Massachusetts: TRANSFARE Program

Since 1978, the elderly and handicapped populations of Lawrence have had their transportation needs supplemented by the TRANSFARE program. The program works as follows: Eligible citizens purchase books of ride tickets, valued at $10.00 for $5.00 each. The tickets have a face value of 25¢ each, and may be used to pay for up to $2.50 of each taxi ride within the Lawrence service area (any excess must be paid for in cash). The tickets are accepted by all nine taxi operations in the city. For each TRANSFARE trip, the taxi driver logs the passenger's name, the trip origin and destination, and the time the trip is taken. Every two weeks, the taxi operators submit the logs, are reimbursed in arrears, for the face value of the tickets accepted.

The City of Lawrence initiated the idea of the TRANSFARE program and actively pursued grant money available through a Federal demonstration program. The city's effort was led by Mr. John Pavlenkov, the appointed program director. The city had two major related goals for TRANSFARE: to ensure that the program's clients receive the same amount and quality of service as non-subsidized taxi riders while at the same time maintaining the market structure of Lawrence's taxi industry.

When the idea of the program was first raised, all the operators were skeptical of dealing with the city. They were concerned about promptness of payment by the City, and about having their accounts audited. Pavlenkov understood that for the program to be successful it had to have the full support of the operators. Pavlenkov's strategy for achieving this support was to include the operators in the program development. He had many meetings with the operators during which he elicited their ideas on how the program could be structured and the contract written to counter any misgivings they had. A series of "what if" scenarios were discussed before the program and contract were adopted. In fact, the operators had a great deal of input in determining the form and content of the final contract.

Because of the nature of the program, no RFP per se was necessary. As described above, the program was developed through negotiations between Pavlenkov and the operators. This open and personal communication resulted in the opportunity for all parties to express their concerns and desires throughout the program development stage. It produced a contract that is responsive to the neec of all parties. A bid process was not used and was not required because of the demonstration nature of the program and because the intention was to work within the structure of the existing taxicab industry and to include all companies that were interested in participating. In fact, all of the taxicab companies in Lawrence did elect to participate.

The contract is an eleven-page document containing ten sections. Topics include description of the program and the service area; termination procedure; operating procedures (including those for reimbursement); general obligations of the provider (including employee training, vehicle maintenance, accounting practices, reporting procedures, insurance requirements); records to be kept; EEO and MBE requirements.

At the time of the case-study, all those concerned with the program--the clients, the operators, and the city--appeared satisfied with the program. there were about 4500 persons registered to sue TRANSFARE, and the program was supplying approximately 10,000 rides per month.

Cleveland, Ohio: Community Responsive Transit (CRT)

Community Responsive Transit (CRT) is a special program of the Greater Cleveland Regional Transit Authority (RTA) that serves the elderly and handicapped of the City of Cleveland and Cuyahoga County. The program service area covers 464 square miles and is divided into eighteen service districts. RTA supplies service to the seven districts in the Cleveland city limits, while the remaining eleven outlying districts are serviced by Yellow Cab Company of Cleveland under a three-year contract with RTA. Although the service is supplied by two distinct entities, operationally it is one program. Eligible citizens call the telephone number for their service area the day before they wish to make a trip. Every service district has its own local telephone number, but all calls are channeled to a centralized dispatching office at the CRT central office. The operators key information about the required trip into a computer which then develops routes for the following day. Routes for both the in-house and the contracted service are printed out daily and distributed to the drivers. Persons can make trips for any reason, but are restricted to their service area.

The concept of contracting out elderly and handicapped services was present from the beginning, and because of this, RTA decided to involve a taxi operator in the design of the program. Preliminary research indicated that Yellow Cab was the largest of the cab companies in the Cleveland area and would thus likely be a future participant in the program. Thus, Yellow Cab was contacted for input into the design of the program, but with the knowledge that a competitive bid procedure would be used to actually award the contract.

Those most closely involved with the design of the program and its associated contract were Mr. John Terango, RTA's Director of Transportation, Mr. Anthony Monachino, RTA's Superintendent of CRT Operations, and Mr. Leroy Kiely, President of Yellow Cab of Cleveland. These three men met regularly between 1975 and 1976 and worked closely together to design a program that would best serve the elderly and handicapped of the region. They discussed various sizes and shapes of service areas to decide on the most logical, and decided that the program as it is currently structured was the best way to coordinate service efficiently and effectively. They also worked together to gain the confidence and necessary support of 350 social service agencies, and their clients, in the the Cleveland area.

On 1 July 1976, RTA put out an RFP for one-third of the CRT program. This RFP was designed to be the major element of the final contract. It contained thirty-six topics, including requirements of bidders; tax requirements; insurance requirements; specifications (including the number and type of vehicles required, a description of the service required, required maintenance, and a description of those eligible for the service and the requirement that eligibility be checked); reporting procedures; contract duration; EEO requirements. All topics were covered in ten pages of clear, easy-to-understand language. Bids were due by 1 September 1976 so that service could begin on 1 October. Although three bids were received, only Yellow Cab was actually capable of performing the service described in the RFP. The actual contract between RTA and Yellow Cab is a single sheet of paper stating that for three years, Yellow Cab will perform the services stated in an Addendum (the RFP) for the bid price.

At the present time the parties to the contract note that the business relationship is characterized by a high level of cooperation and open communication, mutual trust, and a contractual relationship that is more like a partnership than a hierarchy. Both parties also agree that the terms of the contract, while important, are not so rigid that variations cannot be tolerated. Acceptance of this flexibility has allowed aspects of the program to be changed, for the better, without disruption of service to renegotiate the contract.

At the time of the case-study, there were no major changes planned for the program and its funding sources were relatively secure. The only apparent problem was a lack of vehicles to meet the demand for trips, but neither this problem nor its solution were seen to be related to the contract. The program was handling about 32,000 rides per month, offering service to approximately 16,000 people.

Hartford, Connecticut: Dial-a-Ride

Hartford's Dial-A-Ride program is a transportation program for the elderly and handicapped. The current program had its origins in a Model Cities program.

Under Model Cities Hartford provided each area of the city with a vehicle to be used to provide transportation for the elderly and handicapped. Under this program, service was uncoordinated, very inefficient, and many of the vehicles were not well maintained. In 1972, the city moved toward both consolidating service, and getting out of the transportation business. It was felt that less expensive and more flexible service could be obtained in the private market.

Personnel changes since 1972 prevented us from determining how the program was originally designed or how Yellow Cab of Hartford happened to be awarded the first contract. In any case, a contract was drawn up between Yellow Cab and the City of Hartford to provide transportation for the elderly and handicapped, using the vehicles which were inherited from the Model Cities program. The contract ran for only one year, but permitted annual renewal for four subsequent years. The actual costs of the contract were to be renegotiated annually based on changing operating costs. The program was rebid and a new contract rewritten in 1976 and again in 1981, although both of these versions left the program structurally unchanged with Yellow Cab as the service provider.

Despite the long association between the city and Yellow Cab, relationships between the two are not good. Since its inception in 1972, five different people have run the program for the city. The current manager is Tom Phillips. At Yellow Cab, the current owner, Bill Cotter, took over about three years ago. This is, in fact, the source of the problems. Both parties are functioning within an historical framework which neither of them designed and which neither of them like.

The program is structured so that the city provides the vehicles, gasoline, maintenance, and office space for operation of the program. The contractor is responsible for back-up vehicles; providing heated garage facilities for the vehicles; hiring and supervising drivers and operations staff; certifying eligible clients; and purchasing insurance coverage. Thus the program is very much a shared enterprise in spite of the fact that it is contracted to a private provider, and the city originally did not want to be in the transportation business.

The city uses a formal advertising bid process and awards the contract to the provider who offers the lowest cost per trip. Interested bidders receive a package of materials which includes (1) general specifications for the contract; and (2) special instructions which outline in extreme detail how the program is to be operated. The second package of instructions is a direct product of the deteriorating relationship between the city and Yellow Cab and essentially represents an attempt by the city to have more control over the contractor.

From Bill Cotter's perspective, the major problem with the program is that moving people in vans is an expensive, inefficient method of transportation. He would prefer the use of shared-ride taxicabs. He feels the city does not understand his basic motive of profit, and he finds the constraints imposed on him frustrating. Beyond this, he believes the bid process prevents him from developing the quality or depth of experience that he would like to have in his staff. In order to bid low, salaries must be kept low. This acts to deter his best staff from remaining with the company for very long.

Tom Phillips's major complaint about the program is that there have been a series of problems which have given the program a bad image. Most of the problems involve reliability of the service and insensitivity of the drivers to the clients. The reliability problems can be traced to the city's public works department, over which Phillips has no control. Phillips has, however, felt a similar lack of control in his dealings with Cotter. He cited a number of specific problems which have been difficult to solve as well as a general lack of enthusiasm on Cotter's part in attempting to solve image problems. In order to improve the program image, Phillips wrote several new provisions into the 1981 contract. These were perceived as stop-gap measures and unnecessary irritations by Cotter.

He feels that a structural overhaul of the program is necessary if problems are to be solved.

As mentioned earlier, the distribution of program functions requires constant communication between the city and the provider. At the time of the case-study, however, most of the interactions between the two men were occurring through memoranda. Both preferred to keep direct contact to a minimum.

All of this conflict did not portend well for the long-term life of the contract. Cotter was seriously considering not bidding at the next renewal date, and Phillips felt the program should be taken over and operated by a city department.

Portland, Oregon: LIFT Program

Portland's LIFT Program was established in 1975 as the major part of a six-part program to serve the transportation needs of elderly, handicapped, and rural residents in a three-county area in and around Portland. Although originally operated by Tri-Met, Portland's public transit authority, Tri-Met's role in the program changed in 1979. Tri-Met now serves as the broker and coordinator of transportation services. Human service agencies who wish to provide transportation for their clients contact Tri-Met, which then contracts with other providers to deliver the actual services.

The procedure to select transportation providers is somewhat complex, because of two factors. First, because a very large geographical area is involved, it has been necessary to contract with four different providers in order to deliver all the service. Four different contracts are necessary because of variations in the geographical areas and types of service provided. Second, under Oregon law a public entity, such as Tri-Met, that wishes to contract with another public entity is not required to use a bid procedure. On the other hand, if the contract is to be made with a private entity, an

RFP is required. Thus, in three cases a bid process is followed and one case it is not.

In the three cases where the private sector is involved, potential providers respond to a lenghty RFP by participating in a two-step bid process. The RFPs, written by Tri-Met are about 25 pages in length and are divided into seven (7) major sections. The specifications describe in detail the design of the program including how much money will be spent to provide service and the particulars of business relations and paperwork flow with Tri-Met. Only a few aspects of the program design are left up to the contractor, such as number and type of vehicles.

In the first stage of the bidding process, potential contractors submit their qualifications and Tri-Met determines whether the firm is responsible and able to provide the service. Any firm pre-qualified in the first stage is permitted to submit a bid in the second stage. During the second stage firms simply state how many trips they will provide for the dollar volume Tri-Met intends to spend in the service area. The firm offering the greatest number of trips is awarded the contract.

In practice, the bid process and program administration have been fraught with problems:

1) The Tri-Met Legal department insisted on the two-stage bid process in order to ensure that final selection of the transportation provider is as objective as possible. Tri-Met personnel charged with implementation of the program, however, feel that although this does prevent unqualified firms from bidding the unit evaluation measure allowed in the final bid award prevents such variables as fleet size, experience, and length of trip from being evaluated.

2) Providers who have been under contract with Tri-Met for a number of years voice a similar complaint by noting that the experience they have gained in running the program seems to have no special value in the bid award process.

3) All of the providers who bid and are currently under contract complain that although the bid process suggests that efficiency is a goal of the program, the fact is that the contractors are paid for actual costs rather than the number of trips. The final payment for service bears little relationship to the original bid for number of trips. In fact, nobody knows how much the trips cost or how efficient the service is.

4) Providers also complain that the bid process acts to alter demand for transportation services. In order to keep costs down but still offer the number of trips required, it is advantageous to provide the shortest, most flexible easily grouped trips, not necessarily the trips the client population needs most. This is especially true where remote areas are being served for the same system average trip cost as in more densely populated areas.

It is interesting to note that the provider most satisfied with the LIFT program is the public provider who negotiated a contract directly with Tri-Met. No RFP was used.

In spite of problems, which are regarded as serious by the contractors, the LIFT program is conducted with a cooperative spirit. Tri-Met has tried to respond to the problems of the contractors. On the other side, the contractors are interested in providing the service and would like it to continue. They think the brokerage system is good, and that Tri-Met brings a higher level of knowledge about transportation to the process than would the human service agencies.

Conclusion

In reviewing the results achieved and the processes used, it does appear that there is a certain attitude and pattern of activity which is more likely to result in a successful third-party transportation service contract. There are major differences between the processes used in Lawrence and Cleveland, as opposed to those used in Portland and Hartford. Lawrence and Cleveland both began the contracting process with negotiations. Both cities approached their potential contractors with no preconceived notion other than public and private entities could work together to produce manageable programs. The open communication which was initiated by each of the cities as they began the contractual process resulted in a high level of interest, cooperation, and trust from the private sector companies. Throughout the processes, input was solicited from the potential contractors, and their ideas were in fact used in the final design of the program. After award of the contracts, the open working relationships fostered a flexibility which made it possible to resolve problems as they arose, further ensuring the successful continuation of the contractural arrangements.

There was a difference, of course, in how the two cities finally selected their contractor(s). Lawrence signed contracts with every party that wished to participate in the program, thus precluding the need for a bid process. Cleveland, on the other hand, chose Yellow Cab as the contractor based on a formal advertised bid.

A second observation regarding the negotiation processes used in Lawrence and Cleveland is that they produced program designs which are relatively simple. Responsibilities of each of the parties are clearly spelled out, none of the parties is overly dependent on another to perform its function, and none of the parties is overly burdened with administrative headaches. These results would logically seem to be a direct result of designing programs based on known resources and working through a process sensitive to the administrative duties being imposed on each other.

In contrast, the approach of both Portland and Hartford, (because it was required by law) was to begin the contractual process with the development of a formal RFP which described in detail how the program was to be operated. This procurement process, which is intended to maximize free and open competition, requires a final bid comprised of a single number so that bids from different companies can be compared objectively.

Throughout the transportation industry, there has been much discussion of the merits of different unit measures. Hartford and Portland both used a "flat rate" measure wherein the agency determines in advance how much money will be spent and the service provider bids on the number of trips he can afford to provide for the price. Unfortunately, while the unit chosen for comparision does afford easy comparison of companies on the chosen measure, it usually only measures quantity of service. Variables such as fleet size, previous experience, and other elements which comprise quality of service are ignored. In Hartford, especially, the critical issue had become quality of service with the city and the contractor at great odds as to what comprised quality service.

While the bid process used in these two cities does truly offer free and open competition, the city has complete control over the design of the program. It is left to the successful bidder to fit into the program as best he can.

As previously noted, the Tri-Met case poses an interesting example in that both competitive advertising and negotiation were used to secure contracts. The County with whom they conducted the negotiation was the only one of the four contractors that was completely satisfied with the contract.

In further contrast to the Lawrence and Cleveland cases, the Portland and Hartford programs are organizationally complex. The "theoretical" programs described in the RFPs have required numerous practical modifications to accommodate the "real" contractors, thus producing many administrative headaches. Portland's problem is largely a result of the enormous geographical area they serve, the fact that they have many contractors, and the complexity of trying to fit numerous unique organizations into one system. In Hartford, much of the complexity is a result of the city's insistence that it retain responsibility for some aspects of the service. The result is that two very independent parties are dependent upon each other to deliver the service. Conflict has thus been built into both program designs.

Recommendations

The success of the programs designed and implemented in the cities of Lawrence and Cleveland can be attributed to the negotiation processes which were used. It makes sense, intuitively, that if the parties to a contract work together to design a program based on the assests that each brings to the agreement, the likelihood that they will arrive at a mutually agreeable and manageable solution is greater. For this reason, we recommend that parties seeking to enter a contractual arrangement for transportation services negotiate to determine the design and management of the program.

Fortunately, with the advent of UMTA Circular 4220.1A, Guidelines for Third-Party Contracting, it is now possible for many organizations who receive UMTA funds and who have third party contracts to negotiate service contracts. UMTA now sanctions competitive negotiation when conditions are not appropriate for the use of formal advertising. As previously discussed, a single unit measurement is not, in most cases, an appropriate evaluation measure of complex transportation service contracts.

Competitive negotiations for transportation service contracts should be conducted as for any other competitively negotiated contract. Anyone interested in using the procedure should consult Circular 4220.1A and appropriate UMTA or State personnel with questions. Very generally, the competitive negotiation process is as follows: Proposals should be solicited from several qualified sources using an RFP. The RFP, however, need not spell out the detailed design of the program as was done in Hartford and Portland. It should cite what is generally required, with specific details included where necessary (such as levels of insurance required). The RFP should identify all significant evaluation factors, including price or cost where required and their relative importance. Procedures for technical evaluation should be developed and then the bids which were received should be evaluated accordingly. After the evaluatic procedure has identified the vendors offering the best proposals, the public entity may engage in negotiations with those vendors to arrive at the best and final offers. Award may then follow to the responsible offerer whose proposal will be the most advantageous to the public entity, price and other factors considered.

While this system does not offer quite the openness and flexibility of the system used in Lawrence, it is a major improvement over the formal advertising process which has often been required to enter a service contract. Within the allowable negotiation process, it should be much easier to arrive at a mutually agreeable program design and contract than has been possible previously.

Volume

2

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REPORT OF A SURVEY ON ARCHITECTURAL ACCESSIBILITY BY THE VISUALLY IMPAIRED

Abstract Prepared For

Third
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and
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Abstract

This report presents the findings of a survey on architectural accessibility that involved the administration of a questionnaire to a group of 108 visually impaired people mostly living in the Melbourne metropolitan area. The survey addressed a range of questions raised by the contents of the PRE POSTAL BALLOT DRAFT of AS 1428 (The Australian Standard for Design for Access by Disabled People) issued in May 1983. In addition, the report presents a number of subjective and technical comments on the content of the draft standard.

The survey was jointly funded by a grant from the Australian Research Grants Commission, and by the Association for the Blind (Victoria). Assistance was also provided by the National Federation of Blind Citizens of Australia.

In this report:

Section one: lists several technical points noted by the authors.

Section two: gives some subjective impressions on a range of aspects

Section three: presents the results of the survey (Architectural Accessibility).

In each section the points are given against the respective section numbers and headings as they appear in the draft standard.

THE RESPONDENTS

The questionnaire was completed by 108 people; all but 15 of whom are living in the Melbourne metropolitan area. The participants responded to requests made by staff at the Low Vision Clinic at Kooyong, by the organizers of the Victorian Blind Cricket Association, made over the radio station 3RPH, and from many other sources. They were selected on the basis of both their age and level of vision, and on their apparent level of activity.

The group was generally fairly active, with 80 (76.2%) walking at least several blocks on most week days and a further 16 (15.2%) walking one day per week. Overall, the biographical characteristics and the levels of visual acuity of the respondents were well spread across the range of possibilities: there were 59 (54.6%) males and 49 (45.4) females. There were 43 (40.2%) persons aged 15-34 years, 42 (39.2%) aged 35-64 years, and 22 (20.6%) aged 65 years or over (one age was not given).

On visual acuity, there were:

Totally blind	32	(29.6%)	13	(41.9%)	from birth,
Near totally blind	15	(13.9%)	2	(13.3%)	from birth,
Profoundly low vision	44	(40.7%)	20	(45.5%)	from birth,
Severe low vision	14	(13.0%)	2	(13.2%)	from birth,

There were also two respondents who classified their vision as moderately low and one respondent as near-normal.

VEHICLE DISPATCHING SYSTEM FOR SPECIALIZED TRANSPORTATION

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Introduction

The effectiveness and efficiency of a demand responsive transportation system for elderly and handicapped persons depend heavily on the vehicle dispatching scheme. Operating efficiency, operating cost, vehicle and driver requirements, and passenger satisfaction are affected by the manner in which vehicles are dispatched to meet passenger demand. Because of the dispersed passenger trip origins and destinations, and desired departure times, the vehicle movements of demand responsive system contain a significant share of empty vehicle miles and idle time in the daily operating cycle; for example, Delaware's demand responsive transportation, DAST's (Delaware Administration for Specialized Transportation) operating statistics in fiscal year 1983 shows that 35% of total annual vehicle miles are empty miles, and 50% of annual driver hours are empty travel or idle time. The vehicle loading is two passengers per non-agency vehicle trip. Scheduling of vehicles to increase passenger loading and to reduce empty vehicle travel and idle time, therefore, is an imperative element of vehicle dispatching.

This paper discusses the objectives and problems associated with vehicle dispatching, first, and then proposes a vehicle dispatching method to minimize empty vehicle travel.

Vehicle Dispatching Practices and Problems

A typical demand responsive transportation system handles two types of passengers: regular pre-registered passengers who repeat trips on certain days (e.g., visits to doctor's office or treatment), and occasional passengers. The regular passengers' trip information is usually known to the dispatchers. The occasional users are required to make trip reservations well in advance, typically 24 hours prior to their trips. Each request contains name, origin/destination addresses, sponsoring agency (billing agency), type of disability, and trip start/return times. The dispatcher compiles all the trip requests (regular and occasional) and develops vehicle routings for the next day. In developing the vehicle routings, at least the following aspects are considered:

- Passenger satisfaction: maximum satisfaction of passenger trips with minimum passenger inconvenience and comfort, including minimal time adjustment and circuitous path.

- Equitable route assignment among drivers: fair and equitable allocation of the number of trips, the number of passengers, miles, hours and area coverage among the drivers.

- Operating efficiency: maximum passenger loading and minimum empty vehicle travel and idle time to reduce operating cost.

An increase in vehicle loading is achieved by aggregating passengers with close proximity in origin/destination addresses and departure time. The level of passenger aggregation poses trade-offs between passenger convenience and operating efficiency; the more passengers are aggregated, the more passengers are inconvenienced by extra travel time and distance and adjustment of trip start time, while the operating efficiency generally increases. Passenger comfort which is inversely affected by the passenger loading is another consideration with the level of aggregation. These trade-offs must be taken into account in achieving the first and third objectives. Vehicle breakdown, travel time changes due to traffic conditions and changes in passenger trip requests (cancellation, no-show and time or destination changes) are additional elements which affect operating efficiency and make vehicle dispatching a complex task.

In the next section, a vehicle dispatching method which minimizes empty vehicle travel distance and time will be discussed.

Vehicle Dispatching Model: Objective and System Environment

The objective of the model is to assign vehicles between passenger drop-off point/time and passenger pick-up point/time so as to minimize empty travel time and idle time. In developing the vehicle dispatching model, the service area is divided into zones, and the operating hours (typically, a day or half a day) are divided into time periods (for example, 10, 15, or 20 minutes). When a passenger trip request is received, the origin and the destination addresses are converted to the corresponding zone numbers; the desired departure and estimated arrival times are registered in the corresponding time periods. The empty vehicle movements are then optimized based on both zone-to-zone and time period-to-time period movements.

The outputs from the dispatching algorithm include:

- Routing instructions for each vehicle: a travel sequence with respect to locations and time (garage to garage),
- Fleet size required to meet the passenger trip requests,
- Identification of passenger trip requests which cannot be satisfied with the given fleet size,
- Estimated vehicle miles and hours (loaded and empty trips, respectively).

The model is most effectively applied to a system with the following operational and passenger characteristics:

- Passengers make trip reservations well ahead of the desired departure time.
- Vehicles start from a garage (or garages) at the beginning of the day and return to the originating garages at the end of the day.
- Vehicles are equipped with two-way radios to communicate with the dispatcher.
- Vehicle travel time between any two points in the service area is relatively stable. Desirably, the travel time variations are less than the interval of a time period.

Optimization Algorithm

To facilitate the explanation in the following sections, a demand responsive transit system consisting of four zones and one garage (which is located in one of the zones) will be used as an example. Figure 1 shows the example service area and the zone designations. Tables 1 and 2 are the matrices of relative travel time in time periods and travel distance for all zone pairs. In Table 1, "zero" entries indicate that the corresponding trips are accomplished within the time period.

The schedule development process consists of the following steps:

Step 1. Compilation of passenger trip requests,

Step 2. Development of optimum empty vehicle movements, Step 3. Development of vehicle routing instructions.

Step 1: Compilation of trip requests. Each passenger trip request contains at least, the following attributes: origin and destination addresses and desired departure time. The trip origin and destination addresses are translated into their respective zone numbers; thereby, each passenger trip is registered as a zone-to-zone trip. This process is carried out manually by the dispatcher when the trip request is registered, or automatically by a computerized address coding system. Similarly, the desired departure time is translated into the corresponding time period. Using the zone-to-zone travel time matrix, the arrival time period at the destination zone is also determined.

Each trip request now bears the following four attributes: origin zone number (= i), destination zone number (= j), departure time period (= m), and arrival time period (= n).

All the passenger trip requests are summarized in a matrix in which each element shows the number of trip requests which have the same trip attributes: origin zone, and departure time period, and the destination zone and arrival time period. This matrix is called a passenger trip request matrix and is shown in Table 3.

The passenger trips are then translated into the corresponding vehicle trips by dividing the elements in Table 3 by the vehicle capacity as shown in Table 4.

Step 2: Development of optimum empty vehicle movements.

(1) Problem formulation. In Table 4, the row at the bottom represents the total number of vehicle arrivals at each zone and time period. Since a loaded vehicle arrival means that the vehicle becomes available for an empty trip, the bottom total row of Table 4 represents an empty vehicle supply at respective zone and time period. By incorporating the empty vehicle supply at the garage before the day's operation (at time period "zero"), the empty vehicle supply vector is presented at the bottom row of Table 4, assuming fleet size of 40. Similarly, the column on the right shows the total number of loaded vehicle departures from each zone and time period representing the empty vehicle demand. Since all vehicles must return to the garage at the end of the day, the empty vehicle demand vector should also include the vehicle demand at the garage at the last time period as shown in the far right column of Table 4.

The problem is how to assign vehicles from the empty vehicle supply zones to empty vehicle demand zones considering time periods of vehicle availability and demand. This is a linear programming transportation or assignment problem with minor complications due to the travel cost functions.

(2) Development of travel cost matrix. In order to solve the linear programming problem, the cost of empty vehicle trips for each zone/time period pair must be known. The unit vehicle cost for each assignment is denoted as:

$T(i,j,m,n)$ = travel cost from zone i (departing in time period m) to zone j (arriving in time period n) per vehicle.

In developing values to $T(i,j,m,n)$, the feasibility of vehicle trips between i and j must be examined first, considering the sequential relationship between time periods m and n. A vehicle is not able to arrive at destination zone j at time period n by departing the origin zone i at time period m, if (1) arrival time period n is before the departure time period: $n<m$, or (2) even $n \geq m$, if the travel time between i and j, is greater than the time difference between time period m and n. Under these circumstances, $T(i,j,m,n)$ assumes a large value to prevent the vehicle assignment in the subsequent LP solution. Otherwise, the values of $T(i,j,m,n)$ may be calculated based on the travel distance only, or on a combination of travel distance and time difference between m and n, such as;

$T(i,j,m,n) = a \cdot d_{i,j} + b(n-m) \cdot e$ (a = cost per unit distance, $d_{i,j}$ = distance between i and j, b = cost per unit time, e = duration of a time period)

(3) Optimization. Since the objective is to minimize the total cost, the sum of the product of cost (a function of distance and/or time) and vehicle volume, the model is now summarized as:

$$\text{Minimize } \{\sum_i \sum_j \sum_m \sum_n [T(i,j,m,n) \cdot X(i,j,m,n)]\},$$

where

$X(i,j,m,n)$ = the number of empty vehicles assigned to the trip from zone i/time period m to zone j/time period n,

subject to:

$$\sum_j \sum_n X(i,j,m,n) = S_{i,m},$$

$$\sum_i \sum_m X(i,j,m,n) = D_{j,n},$$

where

$S_{i,m}$ = empty vehicle supply (availability) at zone i/time period m,

$D_{j,n}$ = empty vehicle demand at zone j/time period n.

Since the total empty vehicle supply ($\Sigma S_{i,m}$) and the total empty demand ($\Sigma D_{j,n}$) are equal, the above formulation is a balanced LP transportation problem.

For the example, using the values of Tables 4 and 5 for $S_{i,m}$, $D_{j,n}$ and T(i,j,m,n), respectively, the problem was solved by a transportation problem package written for APL (A Programming Language), and the derived optimum empty vehicle trip matrix is presented in Table 6. For an actual problem, the sizes of the matrices can be very large due to the combination of zones and time periods. APL, when compared with FORTRAN or BASIC, is particularly efficient for a large size LP problem and matrix operations like this problem.

This LP transportation problem can also be formulated as a network flow problem in which nodes represent loaded vehicle trips and links represent empty vehicle trips connecting loaded vehicle trips (nodes). A link exists only when the empty vehicle trip is feasible between two loaded vehicle trips. The two end points of the network are the garage at the beginning of the day and the garage at the end of the day. The minimum sets of paths which traverse the network passing all the nodes represents the minimum number of vehicles to satisfy the day's travel requests.

(4) Examination of the results. The results of the LP problem must be examined to determine if the solution is indeed feasible. If there is a vehicle assignment to an element for which the travel cost, T(i,j,m,n), is the very large number in the travel cost table, the empty vehicle has been assigned to a trip which is impossible to achieve.

Attention should also be directed to the vehicle assignment from the garage at time period 0 to the garage at the last time period. This value indicates the number of vehicles not used (the number of vehicles staying at the garage throughout the time periods). In our example, the number of unused vehicles is 30; in other words, 10 (=40-30) vehicles are sufficient to handle all the passenger trip requests in Table 3. Since the empty vehicle travel and idle time is minimized, the fleet size shown represents the minimum to handle the passenger trips.

Step 3: Development of vehicle routing instructions.

After the empty vehicle movements were optimized, the next task is to prepare a complete vehicle routing sequence by tracing the empty vehicle movements and the loaded vehicle movements, alternately. Suppose in the empty vehicle trip matrix, S empty vehicles are sent from the garage to zone j/time period n, the next step is to look up the loaded vehicle trip table for movements originating from zone j/time period n. After the destination of the loaded vehicle trip from j/n are identified, then the empty vehicle trip table must again be looked up to follow the movements, and so on. The original S empty vehicles may branch out to take different trip paths; therefore, the vehicle trip sequence is developed by following the empty and loaded vehicle tables alternately, starting at the movements from the garage and ending to the garage on the empty vehicle trip table. In the example, by following Tables 6 and 4, alternately, the vehicle routing instruction for the 10 vehicles were prepared as shown in Figure 2.

The vehicle trip paths identified by zone number and time periods are later replaced by the addresses and the desired departure times originally requested by the passengers, to prepare the individual vehicle routing instructions.

The Procedure for Vehicle Routing Development

The procedure of the proposed vehicle dispatching scheme is summarized as the sequence of the following activities:

Activity 1: The passenger trip requests received by the telephone operator are compiled (preferably a day before).

Activity 2: The origin and destination addresses of the trip requests are identified by zone numbers. (This activity may be conducted at Activity 1 simultaneous to the receipt of trip requests, when the computer address coding system is interactive).

Activity 3: The departure time, and the arrival time estimated by the zone-to-zone travel time table are converted to the respective time periods. Each trip request now carries four attributes: origin and destination zones, departure and arrival time periods.

Activity 4: A passenger trip table is prepared and; a loaded vehicle trip matrix is developed.

Activity 5: The vectors of empty vehicle supply and empty vehicle demand are developed from the bottom row and the right total column of the loaded vehicle trip table, respectively. The number of vehicles in the garage at the beginning and the end of the day are added to the vehicle supply and the vehicle demand vectors.

Activity 6: Travel cost matrix for the LP problem are developed using the zone-to-zone travel distance and zone-to-zone travel time matrices.

Activity 7: The LP problem is solved. The solution is called the empty vehicle trip matrix.

Activity 8: The empty vehicle trip table is examined for validity and the fleet size requirements are determined.

Activity 9: Vehicle routing based on zone-to-zone and time period-to-time period movements is then converted to trip origin address to destination address movements with departure and arrival times specified.

Summary

This paper examined vehicle dispatching functions of a demand responsive transportation system for elderly and handicapped persons and proposed a method to optimize vehicle routing. The method yields the optimum vehicle travel sequence to minimize empty vehicle travel and idle time. Since the unproductive vehicle time is minimized, the derived fleet size is also minimal; thus it is useful not only for schedule preparation, but also for fleet size and driver size evaluation. The procedure is relatively simple to use and is easily computerized. The implementation of the proposed method would bring about energy and operating cost savings in the short run, and the capital cost savings in the long run.

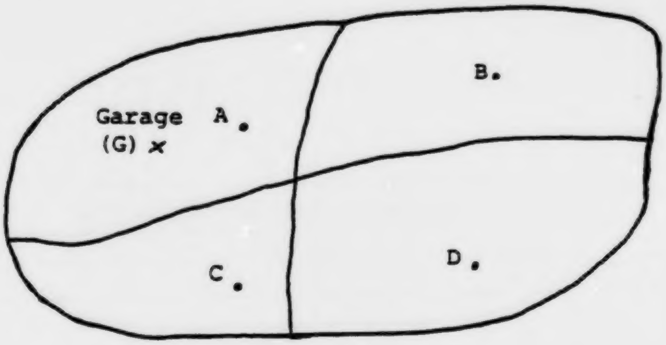

Fig. 1 EXAMPLE SERVICE AREA AND ZONE DESIGNATIONS

TABLE 1 ZONE-TO-ZONE TRAVEL TIME MATRIX

		DESTINATION ZONES			
		A	B	C	D
ORIGIN ZONES	A	0	1	1	1
	B	1	0	1	1
	C	1	1	0	1
	D	1	1	1	0

TABLE 2 ZONE-TO-ZONE TRAVEL DISTANCE MATRIX

		DESTINATION ZONES			
		A	B	C	C
ORIGIN ZONES	A	0	1.0	1.5	1.2
	B	1.0	0	2.0	0.5
	C	1.5	2.0	0	1.0
	D	1.2	0.5	1.0	0

TABLE 3 PASSENGER TRIP REQUEST MATRIX

		DESTINATION ZONES AND TIME PERIODS												
		A			B			C			D			
	TIME PERIODS	1	2	3	1	2	3	1	2	3	1	2	3	TOTAL
ORIGIN ZONES AND TIME PERIODS: A	1					8			9			3		20
	2						5			4			1	10
	3													0
B	1								5					5
	2			10									6	16
	3													0
C	1		1											1
	2						6						4	10
	3													0
D	1					7								7
	2			7			5						5	17
	3													0
TOTAL		0	1	17	0	15	16	0	14	4	0	3	16	56

TABLE 4 LOADED VEHICLE TRIP MATRIX

		DESTINATION ZONES AND TIME PERIODS												
		A			B			C			D			
	TIME PERIODS	1	2	3	1	2	3	1	2	3	1	2	3	TOTAL
ORIGIN ZONES AND TIME PERIODS: A	1					1			1			1		3
	2						1			1			1	3
	3													0
B	1								1					1
	2			1									1	2
	3													0
C	1		1											1
	2						1						1	2
	3													0
D	1					1								1
	2			1			1						1	3
	3													0
TOTAL		0	1	2	0	2	3	0	2	1	0	1	4	16

TABLE 5 ZONE-TO-ZONE UNIT TRAVEL COSTS

		DESTINATION ZONES AND TIME PERIODS												
TIME PERIODS		G	A			B			C			D		
ORIGIN ZONES AND TIME PERIOD		4	1	2	3	1	2	3	1	2	3	1	2	3
G	0	28	7	14	21	8	15	22	8.5	15.5	22.5	8.2	15.2	22.2
A	1	21	0	7	14	M	8	15	M	8.5	15.5	M	8.2	15.5
	2	14	M	0	7	M	M	8	M	M	8.5	M	M	8.2
	3	7	M	M	0	M	M	M	M	M	M	M	M	M
B	1	22	M	8	15	0	7	14	M	9	16	M	7.5	14.5
	2	15	M	M	8	M	0	7	M	M	9	M	M	7.5
	3	8	M	M	M	M	M	0	M	M	M	M	M	M
C	1	22.5	M	8.5	15.5	M	9	16	0	M	14	M	8	15
	2	15.5	M	M	8.5	M	M	9	M	0	7	M	M	8
	3	8.5	M	M	M	M	M	M	M	M	0	M	M	M
D	1	22.2	M	8.2	15.2	M	7.5	14.5	M	8	15	0	7	14
	2	15.2	M	M	8.2	M	M	7.5	M	M	8	M	0	7
	3	8.2	M	M	M	M	M	M	M	M	M	M	M	0

M = Very Large Number incidating impossible assignment, G = Garage

TABLE 6 EMPTY VEHICLE TRIP MATRIX

		DESTINATION ZONES AND TIME PERIODS													
		G	A			B			C			D			
TIME PERIOD		4	1	2	3	1	2	3	1	2	3	1	2	3	TOTAL
ORIGIN ZONES AND TIME PERIODS G	0	30	3	2		1			1			1	2		40
A	1														0
	2			1											1
	3	2													2
B	1														0
	2						2								2
	3	3													3
C	1														0
	2									2					2
	3	1													1
D	1														0
	2												1		1
	3	4													4
TOTAL		40	3	3	0	1	2	0	1	2	0	1	3	0	

VEHICLE

1 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{A} \xrightarrow{(L)} \text{B} \xrightarrow{(L)} \text{A} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 1 2 3 4

2 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{A} \xrightarrow{(L)} \text{C} \xrightarrow{(L)} \text{B} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 1 2 3 4

3 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{A} \xrightarrow{(L)} \text{D} \xrightarrow{(L)} \text{A} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 1 2 3 4

4 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{A} \xrightarrow{(L)} \text{B} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 2 3 4

5 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{A} \xrightarrow{(L)} \text{C} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 2 3 4

6 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{B} \xrightarrow{(L)} \text{C} \xrightarrow{(L)} \text{D} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 1 2 3 4

7 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{C} \xrightarrow{(L)} \text{A} \xrightarrow{(L)} \text{D} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 1 2 3 4

8 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{D} \xrightarrow{(L)} \text{B} \xrightarrow{(L)} \text{D} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 1 2 3 4

9 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{D} \xrightarrow{(L)} \text{B} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 2 3 4

10 LOCATION: $\text{Garage} \xrightarrow{(E)} \text{D} \xrightarrow{(L)} \text{D} \xrightarrow{(E)} \text{Garage}$
TIME PERIOD: 0 2 3 4

L: Loaded Movement
E: Empty Movement

FIG. 2 VEHICLE ROUTING INSTRUCTIONS

SAFETY AND LONG-DISTANCE TRANSPORTATION FOR THE DISABLED

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SAFETY AND LONG-DISTANCE TRANSPORTATION FOR THE DISABLED

INTRODUCTION

This paper deals with the special problems encountered by the disabled in their travels on intercity buses. For the purpose of this paper, the needs of perhaps only a small percentage of the disabled persons have been addressed. However, their number may be quite large. The author claims no expertise in the types of disabilities or their causes. The paper addresses the needs of those individuals who are generally confined to a wheel chair, and may require some or little assistance in boarding or alighting from an intercity bus. Once on board they may be capable of looking after themselves and would require no assistance during the trip, which may last several hours. Family members, friends or volunteers are often available to provide needed assistance and a wheel chair at either end of the trip. It provides the disabled a sense of independence and frees them from the expense of an escort or companion during the trip. Some bus companies, of course, have offered to provide free travel for the companion in their escort service program. However, as the disabled are too aware, the expense for the escort is not limited to the cost of a ticket alone. Requirement of an escort during the trip limits their ability to share those special few days in the year with friends or family, who might live a few hours away.

Bus companies have generally authorized the drivers to exercise full privilege in excluding a person from boarding if the driver feels that it would not be in the interest of 'travel safety'. This 'travel safety' is loosely defined and may imply concern for the safety of other passengers in case the disabled person was dislodged or ejected from the bus seat. The concerned driver has often argued that this may occur during an accident or while the vehicle negotiates a sharp curve or in circumstances of severe braking. The paper examines the forces exerted on a passenger during the travel in a vehicle. Minimum standards of geometric design are assumed to simulate adverse travel conditions that might subject the passenger to the severest forces. The paper provides justification for the requirement of seat belts for a limited number of seats in a bus. It provides even a stronger justification for requiring some rearward facing seats in the intercity buses. Both modifications can be made at a small cost.

NEGOTIATING A CURVE

It may generally be assumed that intercity bus drivers by and large adhere to the posted speed limits in their driving. There is ample justification for this assumption considering the safety record evidenced by their consistently low accident rate. During 1975 intercity buses were responsible for 0.012 fatalities per 100 million passenger miles as compared to 1.2 for the automobiles.(1) During 1978-80 the average death rate for intercity buses was 0.05, while it was 1.3 for passenger automobiles and taxis.(2) Posted speed limits and operating speeds in turn are lower than the design speed which governs the geometric elements of the roadways. Thus, if minimum radii of curves based on Table 1 were provided on rural highways, the maximum coefficient of side friction that the passengers may be subjected to would be 0.16. It would still be nearly one-half the value (0.30) at which the passenger may experience sliding sideways and a sense of discomfort. All this goes on to establish that the occasions on which the passenger may experience discomfort or sliding

TABLE 1

Superelevation (e)		Radius of Curve (ft.) for Design Speed 50mph	30mph
0.06	Desirable for rural highways with snow and ice. Maximum for downtown arterials.	849	273
0.08	Maximum for rural highways with snow and ice and for rural arterials.	764	249
0.10	Maximum for rural and suburban highways.	649	229
	Coefficient of side friction (f)	.14	0.16

Source: AASHTO: A Policy on Geometric Design

during a ride are rare indeed, or infrequent at its worst. The author can personally vouchsafe to this from his experience of having logged 10,000 miles on intercity buses on all terrains in North America. The author does not recall a single incident when he may have had to hang on to the seat in front to keep his balance or when he may have had to apologize to a fellow passenger for sliding into him/her. That is obviously far from being ejected from the seat. Incidentally the author did spend quite a few nights sound asleep during these cross country rides. A person asleep is no less vulnerable than a disabled person when it comes to retaining control, poise and balance under the effect of forces during a ride.

Figure 1 represents side-friction factors for rural highways and higher speed urban streets based on AASHTO policy(3). Figure 2 provides side-friction factors for lower speed urban streets and figure 3 indicates a relation between speed and side-friction factor on curves at intersections based on the same AASHTO policy(3). Higher side-friction factors are allowed in the design at intersections as curves at these locations are not considered in the same category as on the open highway because of the various warning signs provided. Also the anticipation by the driver of more critical conditions at an intersection permits the use of less conservative design factors. However, it is generally clear that higher range of side-friction factors are associated with low speed and much lower values are employed in association with greater highway speeds on curves. Passengers in the bus, of course, may or may not always become aware of the change from rural to urban conditions as much as the driver since they are not concerned with the driving task. In fact, they may quite be preoccupied with other acivities namely reading, conversation or

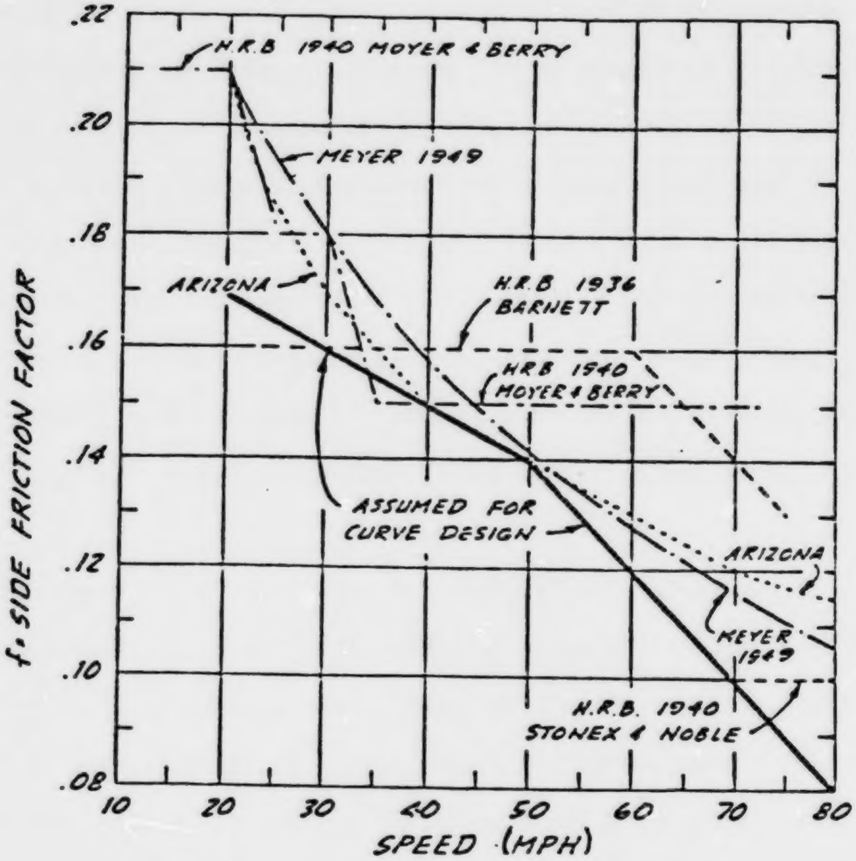

FIGURE 1

Side friction factors for rural highways and higher speed urban streets.

Source: AASHTO: A Policy on Geometric Design

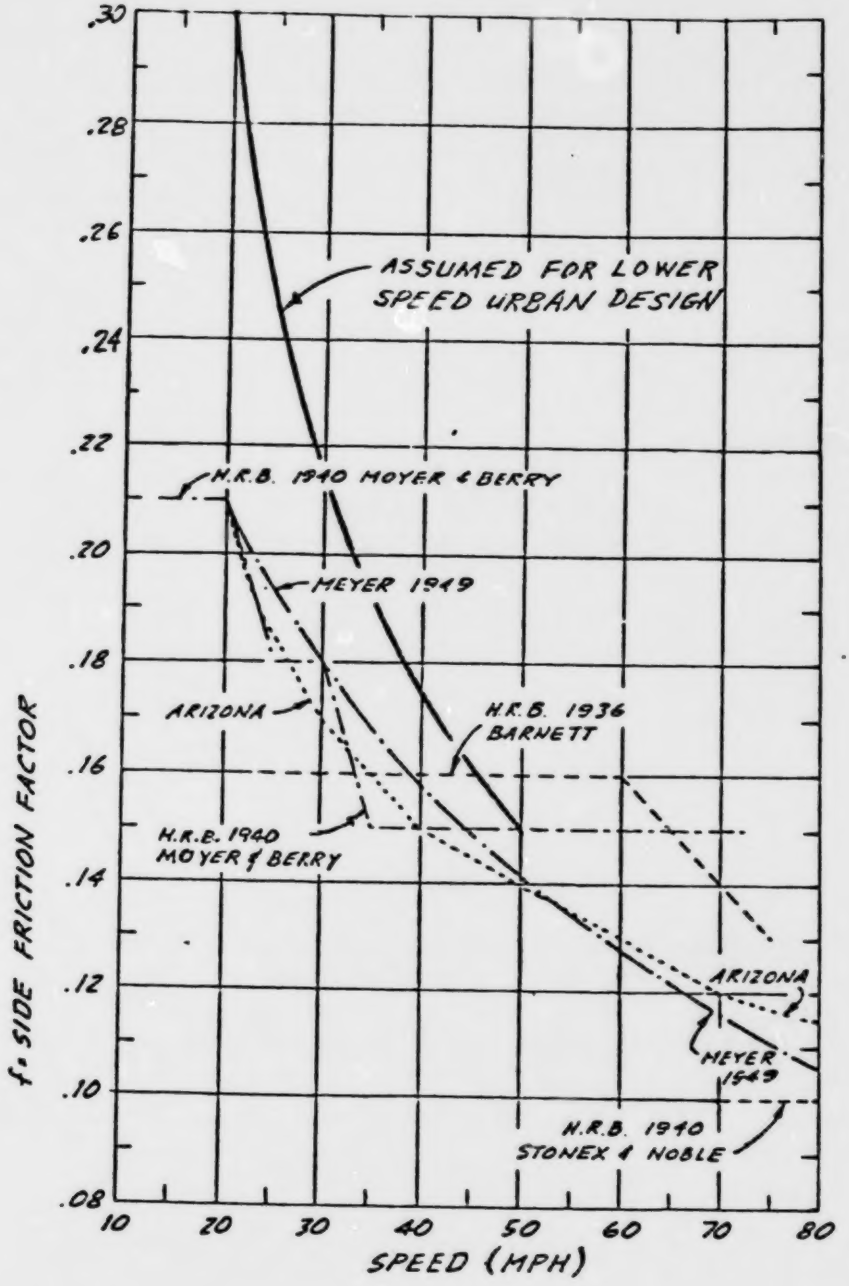

FIGURE 2

Side friction factors for lower speed urban streets.

Source: AASHTO: A Policy on Geometric Design

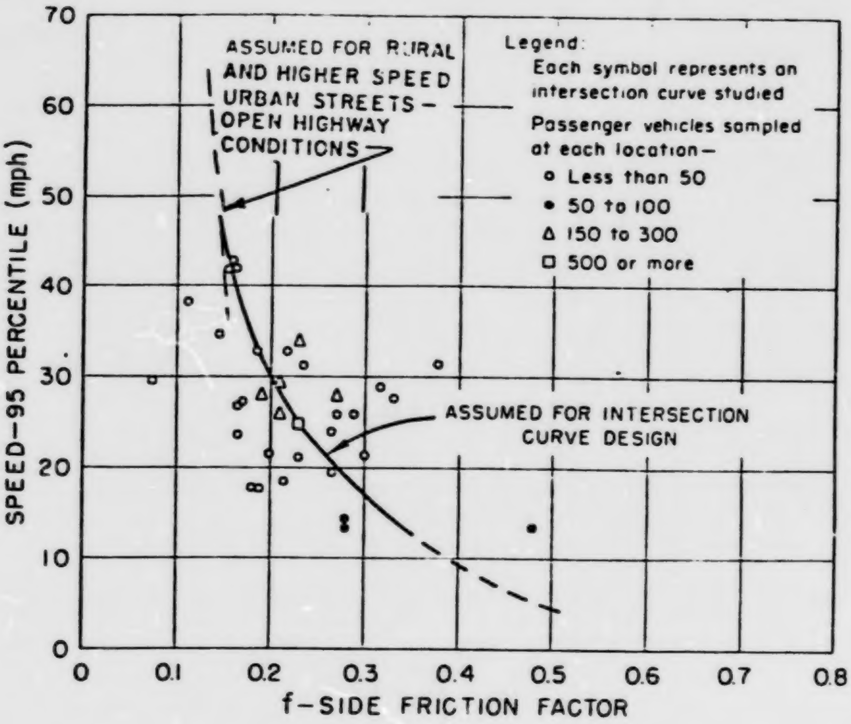

FIGURE 3

Relation between speed and side friction factor on curves at intersections.

Source: AASHTO: A Policy on Geometric Design

soliloquy. Passengers, thus, may perhaps experience a little sway near intersections, but no worse. For them to feel discomfort associated with sliding along the seat, the driver would have to be travelling at 64 miles per hour over a curve which is properly designed for 50 miles per hour. Those conditions are rare, if they ever occur at all. As is suggested later in the paper, if the concern about an individual's ability to support oneself or remain in seat is in question, then a seat belt could be of paramount importance.

CIRCUMSTANCES OF SEVERE BRAKING

Severe braking of the vehicle subjects the passengers to perhaps the largest forces during travel except in the case of an accident. Braking to stop a vehicle from 50 miles per hour on dry pavement can subject the passenger to a deceleration of approximately 19 ft/sec^2 or 0.60g. It has been reported(4) that deceleration rates of 7.0 to 13.9 ft/sec^2 (or 0.22g to 0.43g) occur on approaches to intersections based on an evaluation of driver behavior at signalized intersections. During an accident, particularly a head on collision, the passenger could be subjected to a deceleration rate of 20g if the vehicle were to have its motion arrested in about 4 feet travelling at 50 miles per hour(5). On the other hand, if the vehicle was to stop within 2 feet after hitting a tree or an abutment, the passenger would experience a force of 40g. A simple way of stating this is that a person traveling in a vehicle would experience a force equal to his own weight or less during severe braking, but could be subjected to a force equaling 20 to 40 times his weight during a collision. It is generally accepted that the human body can withstand deceleration of upto 20g without serious injury. These findings are reportedly based on experiments carried out on human subjects and the examination of victims of accidental falls and the like(5). It is perhaps this research which has lead to no requirements for seat belts in buses. A few school districts in the country are currently beginning to require seat belts for all passengers and are ordering their fleet to be modified. We have been aware of the usefulness of passenger restraint systems for years. There is finally a revived enthusiasm and some states have adopted enforcement of seat belt wearing laws.

What is now being considered normal for all passengers in private vehicles, and some public vehicles, at least in some states, is, of course, of paramount importance for the handicapped and the disabled. A passenger restraint system for them is not only essential for their safety during travel, but provides a freedom and worry free environment, which they can independently cope with. Bus companies have indicated that the added cost of providing seat belts for all passengers is prohibitive. But then have also stated that their safety record ensures that there are rare instances, if any, when a seat belt serves a useful purpose for the passengers. Perhaps they are right as intercity bus service has proved to be one of the safest modes of transport over the years. However, the issue assumes a different light for the disabled individual. A passenger restraint system may not be required for all passengers in intercity buses, but it is an essential item for the disabled even when escorted by a companion. A strong justification can be made for the provision of seat belts at least along one row of seats. It can provide the choice of a restraint system to those who so desire, whether disabled or not, but above all, will provide upto four seats, when required, for the exclusive use of the disabled. The cost should not be prohibitive under the circumstances, and in fact, could be greatly reduced when seat belts are installed during the manufacturing stage.

REARWARD FACING SEATS

The most important innovation of all, of course, would be to install some seats facing rearward in the vehicle. Even without a seat belt, the passenger would be pushed into the seat rather than being ejected forward from it during severe braking. As discussed earlier, severe braking causes perhaps the largest forces on the passenger other than during a collision. Code of Federal Regulation is surprisingly silent on the issue of whether to provide rearward facing or forward facing seats(6). It certainly specifies performance standards for rearward facing seats as it does for the forward facing seats. An inquiry from the office of the National Highway Traffic Safety Administration reveals that the Code (49CFR) is aimed at specifying performance standards. It is not for them to suggest innovations in seating arrangement. If the manufacturers choose to include rearward facing seats as part of the design, the performance standards are specified. And why are manufacturers or bus companies not requiring rearward facing seats? In response to this question, at least the bus companies state that they are meeting the regulations and by-laws of the federal and state governments and see no need to suggest any changes in the seating arrangements. Therein lies the predicament. Providing rearward facing seats may seem anomalous to most, but it would be a boon to the disabled, and of substantiated benefit to all passengers. Seats have generally been placed facing foreward as the driver does. No distinct advantage was seen in the rearward facing seats initially and thus it became conventional to provide forward facing seats. This trend has been generally maintained even though public transport vehicles in Europe have occasionally both forward and rearfacing seats in groups. It provides a friendly environment for persons traveling together or for strangers to get acquainted. It is ideal for families traveling with children. A strong recommendation is made to provide at least a small group of seats facing rearward in the intercity buses. It is an innovation which calls for no additional costs when included as part of the design at the manufacturing stage.

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A MODEL OF PARATRANSIT
DEMAND AND SUPPLY

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I. INTRODUCTION

Setting up and operating a specialized service for the handicapped involves an array of difficult decisions and trade-offs. For example, planners must decide whether to serve only severely disabled persons -- those for whom regular transit is physically impossible to use -- or to extend eligibility to moderately handicapped and able-bodied elderly persons as well: they must delimit the geographic range of service and the network of available destinations within that range: and service levels must be established as well, such as advance booking requirements and fares.

Such decisions inevitably involve trade-offs and it is such trade-offs that usually define the planner's forecasting needs. For example, if a locality decides to offer same-day service rather than require a 24-hour advance reservation, the planner must forecast whether the added cost would exceed the available budget. If so, he must examine potential areas for reducing costs, such as tighter eligibility restrictions, and forecast their possible implications.

Proposed Department of Transportation regulations could further reinforce the need for this kind of "trade-offs" forecasting in the 1980's,[1] and a number of States have enacted similar legislative requirements. The proposed DOT regulations establish six minimum service criteria for specialized transportation and introduce the concept of a cost cap that determines the maximum amount a locality would need to spend in providing service. Were a locality unable to meet all six criteria within the cost cap, it could, at its discretion, make trade-offs among all six aspects of service until costs fall within an acceptable range.[2]

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1. See Federal Register, September 8, 1983, 48 FR 40684. The proposed regulations were still in the public comment period at the time of this writing.

2. A locality could, if it chose to, spend more than the upper limit. See 48 FR 40684. The six criteria in the proposed final regulation are, fares comparable to local transit fares; "reasonable" advance request times; no trip purpose restrictions; geographic range of service comparable to local transit service; no waiting lists; and same days and hours of service as local transit.

- Service shall be available for all trip purposes;

- Waiting lists of persons eligible to use the service cannot be established; rather, all eligible users wishing to use the specialized systems must be permitted to do so.

Where a locality cannot meet all six criteria within the cost cap, it can, at its discretion, make trade-offs among the six criteria until costs fall to that level. Two possible cost cap options are defined in the proposed regulation. These are:

- 7.1 percent of the average annual federal assistance received by the local transit authority over the current and pervious two fiscal years; and

- 3.0 percent of the transit authority's operating expenses over the current and previous two fiscal years.

Through lack of any means to forecast the impacts of different levels of specialized transportation for the handicapped, planners have turned to "on-the-street" experiments, demonstration projects, and plain trial-and error. Though necessary, such techniques are costly and time-consuming and can prove divisive by changing consumer expectations only to shift ground again after the experimental period. Out of such experience however has grown a sizeable database of systems and their operating characteristics under a range of service levels[3]. Based on statistical analysis of this database, a model has been developed that enables a locality to forecast the demand and cost characteristics of door-to-door services for disabled persons under a wide range of alternative service levels. This paper describes the model and demonstrates its use.

PLAN OF THIS PAPER

The remainder of this Section reviews the regulatory background. Section 2.0 addresses the relationship between paratransit costs, service levels, and budgetary constraints. The model of paratransit operations provides the basic analytic tool. Section 3.0 examines the kind of trade-offs available to localities in cases where paratransit costs exceed budgetary constraints and demonstrates how use of the model can enable localities to forecast the demand and cost implications of such trade- offs. The technical appendices provide an array of supporting detail regarding the model.

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[3] The data covering 53 systems, were compiled by the Urban Mass Transportation Administration for the years 1979-1980. The data is to be published later this year.

REGULATORY BACKGROUND

Although the proposed regulations described here are not yet in force and could change before final publication, they represent a useful example of the kind of problem the model is designed to solve.

On September 8, 1983 the Department of Transportation proposed thenew regulations[4] to guide local transit operators in complying with the requirements of Section 504 of the Rehabilitation Act of 1973[5] and other legislative mandates The regulations specify transportation options that would meet the requirements of Section 504; they specify minimum criteria governing the level and quality of service; and they set a cost cap that would define operators' financial responsibility in complying with the minimum criteria.

The proposed regulations would allow localities to select their own approach to serving the transportation needs of disabled persons from a range of permissable alternatives. These are:

- o 50 percent of the fixed route bus fleet with wheelchair lifts. In pursuing this approach, the transit authority would have to ensure that half of the buses it operates during peak and off-peak periods are lift-equipped for wheelchair users.

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4. op. cit. 48 FR 40684.

5. Section 504 states that:
"no otherwise qualified handicapped individual in the United States shall, solely by reason of his handicap, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance. Public Law 93-112, 93d Congress, HR 8070, September 26, 1973.

- Specialized paratransit service. According to the regulations, such a system would provide demand-responsive service by means of lift-equipped vans operated by the transit authority or subsidized taxi vouchers. Eligibility would extend, at a minimum, to handicapped and elderly persons who "physically cannot use public transportation".

- A mix of fixed route and paratransit service. Under this approach, the transit operator (might for example) adapt fewer than half the buses with wheelchair lifts (say, 15 percent or 25 percent) while using paratransit service to cover parts of the city not serviced by lift-equipped buses.
  Other combinations would also be permissible.

Transit operators that opt to provide specialized demand responsive transportation, the focus of this paper, would need to meet six minimum service criteria, although only if doing so would not cost more than the specified cost cap. The criteria state that:

- Service shall be available to handicapped persons throughout the same general service area as that served by the regular route systems;

- Service shall be available on the same days and during the same hours as the regular route service;

- The fare for a handicapped person using the specialized service shall be comparable to the fare for the regular route service;

- Advance request time must be limited to a "reasonable time", where "reasonableness" would be determined by the transit operator, after obtaining the views of handicapped persons through a process of public participation.

II. PARATRANSIT COSTS, SERVICE LEVELS, AND COST CAPS

THE MODEL: A TOOL FOR LOCAL PLANNERS

An econometric forecasting model--based on actual operating data from 53 cities with paratransit service--is used here as a basis for developing paratransit costs under alternative types of operation (user-side subsidy versus transit operated services) and alternative levels of service and fares. Technical details of the model are provided in Appendices A and B; its salient features are described below.[6]

Based on service and fare levels specified by the local planner, the model produces a range of forecasts, such as demand (annual trips), productivity (trips per vehicle hour), cost per trip, fleet and driver requirements, total annual cost and revenue from fares. The model operates with any micro- computer and requires no knowledge of computer programming. The user specifies the following details about the system:

- whether the system will be based on the user-side subsidies or provider-side approach;
- fare level;
- whether vehicles will be lift-equipped;
- whether eligibility will be available to all handicapped and elderly persons or only to the severely disabled (those least likely to be capable of using regular transit);

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[6] See Appendix B for details.

- whether a 24 hour advance reservation will be needed to use the service or whether transportation will be available on shorter notice;
- whether the service will be restricted to a geographic area smaller than that served by the regular transit system or whether the entire geographic area will be served; and
- whether only limited destinations (trip purposes) in the service area will be served--such as bus terminals and hospitals--or whether passengers may choose any destination or trip purpose.

The model thus allows for variation in many of the key service criteria listed in the proposed DOT regulations and of key interest to planners generally. The model also allows for variation in urban size, residential density, and vehicle utilization, and it is thus suitable for analyzing the likely impacts of the proposed regulations in different sized cities.

The approach used in this paper is to estimate the operating-plus-capital costs of running a paratransit system in the average sized city in each of four population categories, (see Table 1 for a description of the four population groups). This approach is used for convenience only. The model could just as easily be applied for any specific urban area. The analysis excludes the nation's six largest cities (see Table 1) since their inclusion would substantially distort the analysis for other cities. This is because historically these six cities have received fully 53 per cent of all federal transit assistance.[7]

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[7] See U.S. House of Representatives, Committee on Public Works and Transportation, Oversight of the Federal Public Transportation Assistance Program, May 1982.

TABLE 1: THE AVERAGE SIZED CITIES IN FOUR POPULATION CATEGORIES

POPULATION CATEGORY	NUMBER OF URBANIZED AREAS	AVERAGE POPULATION SIZE
Less than 250,000	197	118,086
250,000 - 500,000	35	356,542
500,000 - 1 million	22	692,732
1 million or more (excluding New York, Los Angeles, Chicago, Philadelphia, San Francisco & Boston.	19	1,573,328

SOURCE: Census of Population

In practice, of course, costs will vary from city to city depending upon local wage rates and other factors (e.g., population density). For analytic purposes such expenses are assumed to be $23.00 per vehicle-hour, the average (in 1983 dollars) drawn from the database for systems that are operated by transit authorities. Taxis used under a user-side subsidy approach are assumed to cost $5.60 per trip[8] including costs for program administration[9].

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[8] This figure is drawn from Peat, Marwick, Mitchell & Co., Final Report CRW Model Review, (Report Prepared for the Urban Mass Transportation Administration), November 13, 1978 — updated for inflation at 10% per annum. This adjustment results in costs consistent with recent (1983) findings of the International Taxicab Association, (from Interview with ITA, August 1984).

[9] Note that cost-per-trip for transit-operated systems hinges upon their productivity (trips per vehicle-hour). If for example productivity is 2.0 trips per vehicle-hour (a typical figure), transit-operated demand response service would cost $11.50 per trip ($23.00/2.0) as compared with $5.60 for taxis. The model estimates productivity for transit-operated systems and combines this with cost per vehicle-hour projections to derive cost per trip. (See Appendix B). For taxi systems under contract, the model uses cost per trip estimates directly.

THE COST OF INDIVIDUAL SERVICE ATTRIBUTES

Annual paratransit costs vary substantially with shifts in service quality. Based on the econometric model, Table 2 displays the estimated cost of providing a very restricted "minimal" paratransit service -- one in which trip purposes are constrained, only part of the geographic area is served, advance reservation of 24 hours or more is required, and other restrictions are in force. The Table then shows the estimated impact of removing each restriction -- not cummulatively, but rather the effect of each restriction singly on the "minimal" system. In summarizing Table 2, Table 3 shows the percentage increase in annual cost estimated to result from the removal of each restriction on the "minimal" system. The largest impact stems from the removal of the 24-hour advance reservation requirement; this alone increases annual cost by nearly 70 percent. Other cost impacts range from 40 percent to 63 percent higher spending requirements, as shown in Table 3.

The need to make trade-offs among various service levels would be governed to a large extent by budgetary constraints. Although some cities might decide to meet certain service criteria regardless of cost, for others the service level provided will hinge on such budgetary constraints. Cities must compute their spending budgets locally; service levels can then be analyzed accordingly, as shown next.

TABLE 2: ANNUAL CAPITAL AND OPERATING COSTS FOR THE AVERAGE SIZED CITY IN EACH POPULATION CATEGORY TO OPERATE A LOW-QUALITY, HIGHLY RESTRICTED PARATRANSIT SYSTEM: AND THE INCREMENTAL COSTS FOR SELECTED SERVICE IMPROVEMENTS (IN THOUSANDS OF 1983 DOLLARS)

	Under 250,000	250,000-500,000	500,000-1,000,000	Over 1,000,000
Minimal System[1]	159	245	317	491
Incremental Cost to:				
Remove 24 Hour Reservation from Minimal System	+104	+166	+214	+334
Remove Geographic Area Restriction from Minimal System	+70	+108	+135	+212
Remove Destination/Trip Purpose Restriction from Minimal System	+92	+124	+184	+290
Remove Restrictions on Days and Hours of Service from Minimal System (see text discussion)	N/A	N/A	N/A	N/A
Eliminate Waiting List (if any -- see text discussion)	N/A	N/A	N/A	N/A
Extended Eligibility to all Transportation Handicapped Persons	+80	+163	+198	+327

SOURCE: Paratransit model analysis presented in Appendix A.

1. The following service attributes are assumed for the hypothetical "minimal" system:
   - Eligibility is restricted to severely disabled persons;
   - Subscription service is required for recurring journeys;
   - Advance reservation of 24 hours or more is required;
   - Destinations and trip purposes are restricted;
   - Geographic range of service is restricted;

Notes: Operating cost per vehicle hour is assumed to be $23.00. The annual costs shown in the Table include both operating expenses and the depreciated capital costs for vehicles.

The incremental costs shown are not cumulative. Cumulative costs are shown in Chapter III.

N/A = Not Available
"Severely disabled" means unable to use the regular route system.
"Transportation handicapped" includes persons able to use the regular route system with difficulty.

TABLE 3: COST IMPACT OF SHIFTS IN SERVICE QUALITY

CHANGE IN SERVICE QUALITY	PERCENTAGE IMPACT ON ANNUAL COST (Average Across all City Sizes)	
	Average Impact	Range Based on One Standard Deviation
Remove 24 Hour Advance Reservation	+68	+35 to +109
Remove Geographic Area Restriction	+43	+26 to +63
Remove Destination/Trip Purpose Restriction	+57	+39 to +82
Extend Eligibility to all Transportation Handicapped	+61	+31 to +98

Source: Estimates in Table 2.

III. TRADE-OFFS PLANNING ANALYSIS

Based on the econometric model, Figures 1 and 2 display estimated annual budgetary requirements for several alternative system designs. The analysis, shown for a range of city sizes, reflects the costs associated with operations under the direct involvement of the transit operator and those where service is delivered by private taxi companies under contract (so-called user-side subsidies). All estimates reflect average estimated impacts of each service attribute (see Table 3) and average hourly costs. A more detailed use of the model would involve a risk analysis based upon standard errors for each attribute, for hourly vehicle costs, and for taxi per-trip costs.

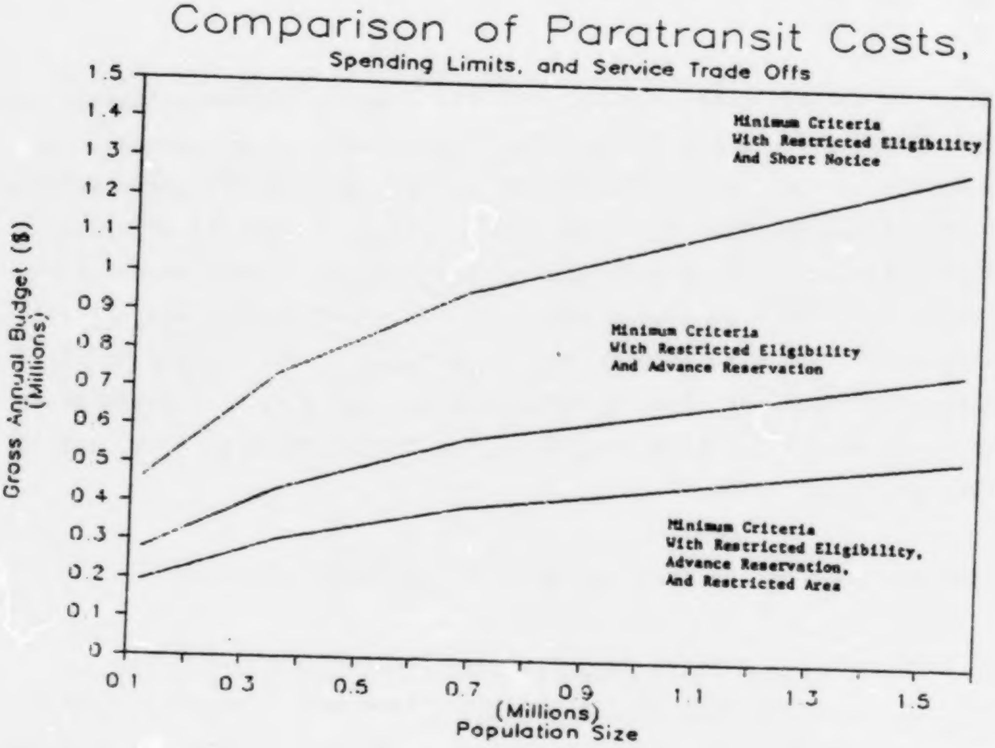
Some key conclusions from the analysis are outlined below:

- For a given budget, many different service level combinations are available (see both Figures). Planners will thus need to compare budgetary constraints with the costs of a wide range of alternatives. Together with disabled residents, priorities can be assigned to individual service attributes in order to generate the locally preferred approach;

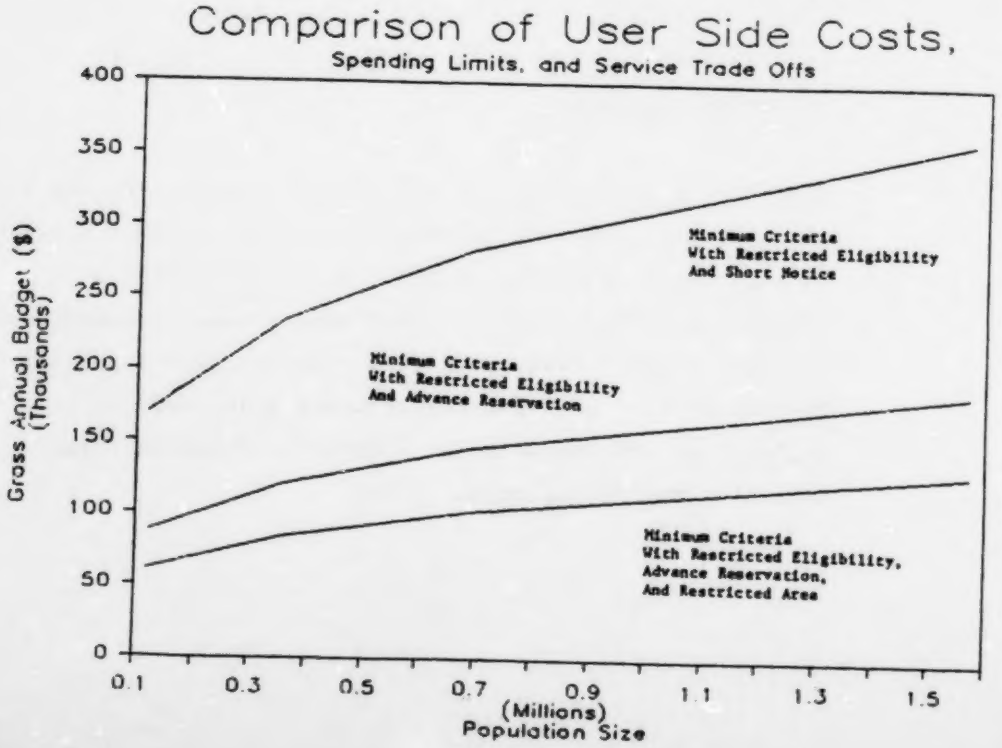
- User-side subsidy techniques cost less (compare Figure 1 top and bottom.) Based on the model analysis, a given service package can be provided at about half the cost of a transit-operated service if user-side subsidy techniques are applied. Some cities would find this approach difficult however because of labor requirements under federal legislation and the need for special vehicles that taxi companies may not operate.

FIGURE 1. GROSS ANNUAL PARATRANSIT AND USER-SIDE SUBSIDY COSTS

(Paratransit costs @ $23.00 per vehicle-hour;
User-side subsidy costs at $5.60 per trip)

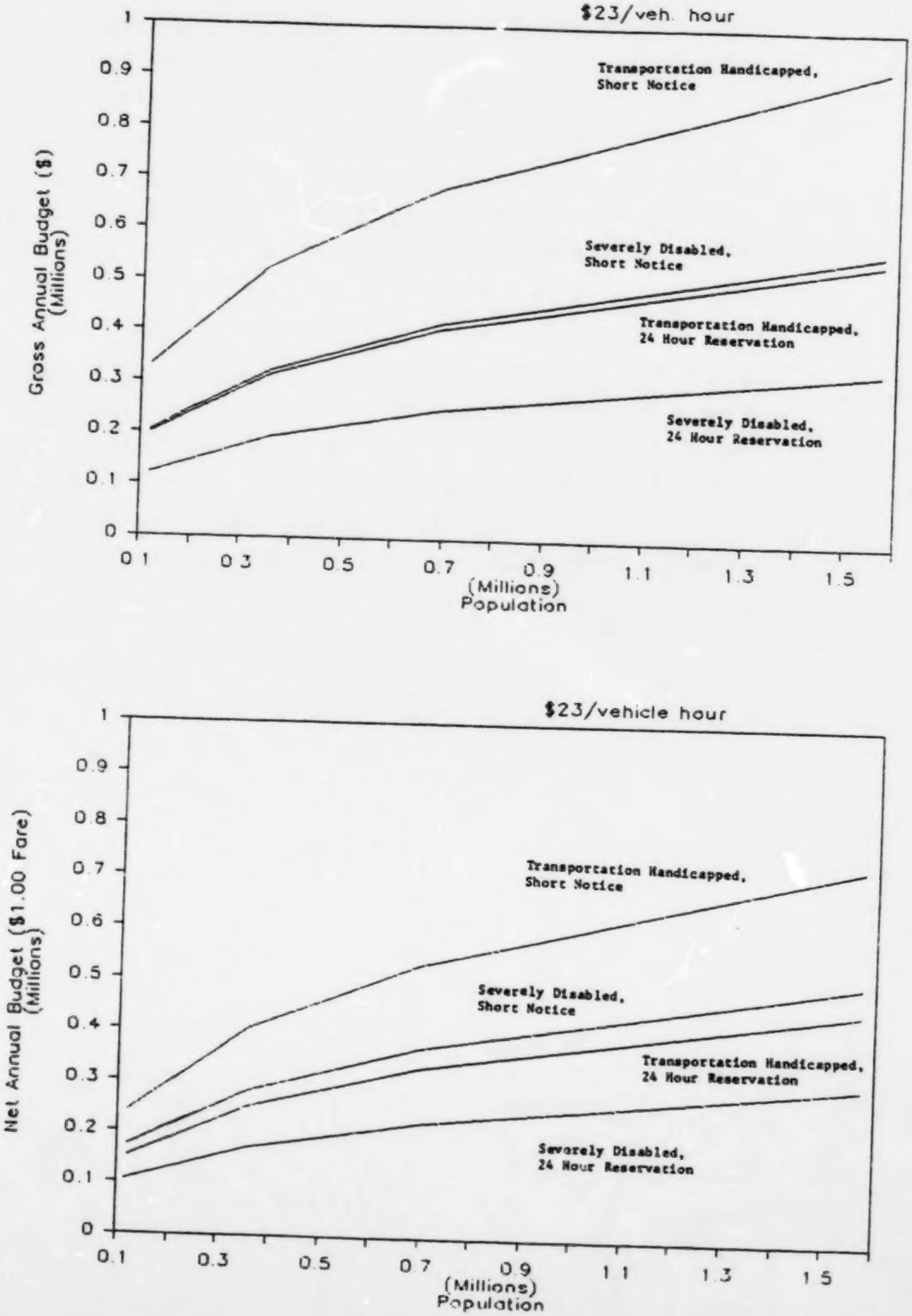


Comparison of Paratransit Costs,
Spending Limits, and Service Trade Offs



Comparison of User Side Costs,
Spending Limits, and Service Trade Offs

FIGURE 2. GROSS AND NET ANNUAL COSTS FOR PARATRANSIT WITH TRIP PURPOSE AND GEOGRAPHIC AREA RESTRICTIONS



- Systems with broadly-based eligibility standards and 24-hour advance notice requirements cost roughly the same as short-notice demand-response service with restricted eligibility (everything else being equal). (see Figure 2.) In cities unable to provide both broad eligibility and short-notice service, a key choice may be that of restricting eligibility to certain groups and providing short-notice service; or requiring 24-hour or more advance notice service but offering specialized transportation to a wider range of handicapped individuals.

- Increased fares help proportionately little to offset gross costs, (compare Figure 2 top and bottom). Local planners may find it impossible to "buy" substantially better service levels for paratransit with revenue from fares (assuming fares to be about the same as regular transit fares) since potential revenues appear small relative to the costs of each service improvement.

IV. CONCLUSION

This paper describes a model that forecasts costs under a range of service levels. The examples given hold for localities with average populations and wage costs. Results will thus vary substantially in individual localities.

APPENDIX A: MODEL ESTIMATION

DEMAND

In most cities that operate specialized door to door public transport, capital and operating budgets are predetermined, and capacity is fixed exogenous of demand. The supply is then rationed through price, eligibility, and service quality adjustments. Accordingly, a demand function may be written as follows:

$$T = f(F,Q,D,Y) \qquad (1)$$

where

T denotes one-way trips carried by the service;
F denotes fare;
Q denotes a vector of service quality variables;
D denotes demographic characteristics of the service area; and
Y denotes income.

Service quality variables cover three factors -- vehicle design, eligibility, and service limitations, as shown in Table B.1. All three variables are used to ration supply.

TABLE B.1: SERVICE QUALITY VARIABLES

Service Quality Variable	Range of Possible Variation
Vehicle Design	Lift-equipped for wheelchairs or not lift-equipped.
Eligibilty	Severely disabled persons only or severely disabled and moderately handicapped.
Service Limitations	Subscription required or not required.
	Advance reservation required (usually 24-hours) or not required.
	Service area restricted geographically or not restricted.
	Length of trip restricted or not restricted.
	Trip purposes served restricted or not restricted.

Data

To estimate a demand function like (1), data was used from 53 publicly operated specialized door-to-door service systems operating in cities across the United States. This sample represents about 2.0 percent of the 2,500 systems estimated to be operating nationwide in 1980. Since few of the 2,500 systems record data of the quality needed here, a random sample of systems was not possible. However, within this constraint the 53 systems were chosen so as to offer as representative a sample as possible. The systems operate in cities from 10,000 to 8 million persons, and display a wide range of service attributes -- including zero-fare service.

The Demand Equation

To help understand the determinants of service usage, the demand function (1) was specified as follows:

$$\ln T/D_i = a + bF_i + cQ_i + d \ln D_i + e$$

where	Ln	denotes natural logarithm
	T/D_i	denotes annual one-way trips per head of population in the i^{th} city;
	F_i	denotes fare in the i^{th} city: 1 if a fare is charged, 0 otherwise;
	Q_i	denotes the service quality variables as follows: Vehicle design: 1 if lift-equipped, 0 otherwise; Eligibility: 1 if limited to the severly disabled, 0 otherwise; Service levels: 1 if subscriptions available, 0 otherwise; 1 if advance reservation required, 0 otherwise; 1 if service area is restricted, 0 otherwise; 1 if trip length restricted, 0 otherwise; 1 if trip purpose restricted, 0 otherwise;
	D_i	denotes population of the ith city; and
	e	denotes an error term of mean zero and constant variance.

Because inter-system income variation among handicapped persons is unknown, the income argument in (1) was omitted.

Using Ordinary Least Squares experiments it was found that fare, population, and four service quality variables (vehicle design, eligibility, advance reservation, and subscription) had the expected signs and acceptable standard errors. Together, these variables explain 68 percent of the variance in trip rates across the 52 systems observed, (Table B.1). The regression coefficients are expressed as percentages in Table B.2.

The Productivity Equation

Defined as trips per vehicle hour, productivity in the provision of specialized transportation (as in any other good or service) represents a key determinant of cost. The statisctical analysis indicates that productivity varies from system to system according to trip density (the number of trips per square mile), the geographic range of the service area, the range of destinations within the service area, and eligibility requirements. Together, these four factors account for 60 percent of the variation in productivity from system to system (See Table B.6). Advance reservation requirements, often thought to influence productivity by enabling ride-sharing, was found to have no appreciable impact on productivity.

TABLE B.1: ORDINARY LEAST SQUARES DEMAND RESULTS

Independent Variable	Dependent Variable $I_n(T/D)_i$ Coefficient	T - Statistic
Constant	3.482388	4.824944
F_i	-0.682608	-1.804704
Q_i		
Vehicle design	0.658127	2.354180
Eligibility	-1.107052	-3.222298
Subscription	-0.331547	-1.310175
Advance reservation	-0.664885	-2.396941
D_i	-0.708373	-7.992168

$R^2 = 0.67515$

Observations = 52

F - Statistics = 15.5878

TABLE B.2: ESTIMATED IMPACT OF FARE AND SERVICE QUALITY VARIABLES ON THE DEMAND FOR DOOR-TO-DOOR SERVICE

Service Characteristics	Percent Change in Annual One-Way Trips Due to Service Characteristics at Left[a]	Statistical Confidence
Fare Charged	-49.5	90.0
No Lift-Equipped Vehicles	-48.2	95.0
Eligibility Limited to Severely Disabled Person	-67.0	97.5
Subscription Required	-28.2	80.0
Advance Reservation Required	-48.6	95.0

Source: Computed from coefficients in Table B.1.

TABLE B.3: ORDINARY LEAST SQUARES PRODUCTIVITY RESULTS

Dependent Variable - Log of Trips per Vehicle Hour

Independent Variable	Coefficient	T - Statistic
Constant	-0.049	-0.136
ln (Trips per Square Mile)	0.230	4.1
Q_i		
Many-to-Many	-0.465	-3.40
Area Restriction	0.361	2.82
Eligibility	-0.370	-2.08

$R^2 = 0.60$

Observations = 37

F - Statistic = 9.58

TABLE B.4: ESTIMATED IMPACT OF SERVICE CHARACTERISTICS ON SYSTEM PRODUCTIVITY (TRIPS-PER-VEHICLE-HOUR)

Service Characteristic	Percent Change in Productivity Due to Service Characteristic at Left	Statistical Confidence
Restricted Service Area	43.0	95
Many-to-Many Operation	-37.0	95
Eligibility Limited to Severely Disabled Persons	-31.0	95
Trips Per Square Mile	0.22 (elasticity)	99

Source, Equation Table B.3.

To be sure, day-ahead service has often been justified as a means of grouping trips for the following day and thereby improving overall productivity. Comparing the systems in the specialized service database, however, it appears that advance reservation has no appreciable effect on productivity, largely because of its negative impact on patronage. That is, while advance reservation creates the potential for ride-sharing, it also surpresses patronage, as discussed earlier. This in turn diminishes the number of trips per square mile (trip density) and thus diminishes potential improvements in productivity.

MODEL STRUCTURE

Based on the statistical relationships between patronage, productivity, and service level variables outlined above, the forecasting model has been developed for use with a micro-computer. The structure of the model is given in Table B.5. Tests of the model's performance have proven accurate within a range of 60 percent of actual systems' demand and cost.

TABLE B.5: SUMMARY OF COMPUTER FORECASTING MODEL: KEY USER INPUTS, MODEL OUTPUT, AND METHOD OF ESTIMATION FOR TRANSIT OPERATED SYSTEMS

	USER INPUT	MODEL OUTPUT	METHOD OF ESTIMATION
DEMAND			
Fare	(yes or no)		
Fare Level	($/trip)		
Restricted to Severely Disabled	(yes or no)		
24 Hour or More Advance Reservation	(yes or no)	Trips Per Head	Patronage Model: Table A.1
		Total Trips	Trips Per Head x Service Area Pop.
Lift-Equipped Vehicles	(yes or no)	Fare Revenue	Trips x Fare per Trip
Subscription Service	(yes or no)		
Service Area Population	(from census)		
SUPPLY			
Service Area Residential Density	(from census)		
Restricted Service Area	(yes or no)	Productivity (Trips Per Vehicle Hour)	Productivity Model: Table A.2
Many to Many	(yes or no)		
Restricted to Severely Disabled	(yes or no)	Fleet Size	$\frac{\text{Total Trips/Trips Per Vehicle Hour}}{\text{Hours Per Vehicle}}$
Vehicle Utilization	(Default = 3000 hours from average of 53 systems)		
COST			
Price of Vehicle	$/vehicle	Fleet Cost	Fleet size x Cost Per Vehicle
Hourly Costs	(From local wage rates or from experience of other systems)	Cost Per Trip	Cost Per Vehicle Hour/ Trips Per Vehicle Hour
None		Annual Operating Cost	Total Trips x Cost Per Trip
Average Vehicle Life	(Default = 5 years)	Annual Budget	Annual Operating Cost + Depreciated Fleet Cost

TABLE B.6: SUMMARY OF COMPUTER FORECASTING MODEL: USER INPUTS, MODEL OUTPUT, AND METHOD OF ESTIMATION FOR USER SIDE SUBSIDY SYSTEMS

	USER INPUT	MODEL OUTPUT	METHOD OF ESTIMATION
DEMAND			
Fare	(yes or no)		
Restricted to Severely Disabled	(yes or no)		
24 Hour or More Advance Reservation	(yes or no)		
Lift-Equipped Vehicles	(yes or no)		
Subscription Service	(yes or no)		
Many to Many	(yes or no)	Trips Per Head	Patronage Model
Resultant Decrease in Demand if Service is Not Many-to-Many	(percent	Total Trips	Trips Per Head x Service Area Pop.
Restricted Service Area	(yes or no)		
Resultant Decreae in Demand if Service Area is Restricted	(percent)		
Service Area Population			
COST			
Average Fare (including cost of prog-admin	$ per trip	Annual Operating Cost	Total Trip x Average Fare
Percent of Fare Charged to User (if fare is charged)	(per cent)	Annual Charge to Users	Annual Operating Cost x Percent Charged to User
		Annual Budget	Annual Operating Cost - Annual Charge to Users

APPENDIX B: COMPUTER PROGRAM

The model operates in BASIC computer language for micro-computers. The program is "conversational", asking the user for all the various inputs as follows:

Answer Y for yes, N for no

Will the system use user-side subsidy? (A "no" reply means system will be operated by the transit system).
Will a fare be charged?
What is the fare?
Will vehicles be lift equipped?
Will eligibility be restricted to the severely disabled (No means all handicapped persons will qualify)?
Will a subscription be compulsory for certain journey types?
Will 24 hour advance reservation be necessary (No means short-notice service)?
Will service be many to many?
Will area be restricted?
What is the capital cost per vehicle in $?

What is the population density of the service area (in persons per square mile)?[1]
What is the population of the service area?
What is the annual vehicle operating hours?[2]
What is the hourly vehicle operating cost in $?[3]

---

1. If the user does not know the population density, the model will estimate it using a statistical sub-model based on the relationship between population size adn population density.

2. If the user does not know the likely annual vehicle operating hours the model will estimate it using a statistical sub-model based simply on averages from other cities.

3. If the user does not know the hourly vehicle operating cost, the model will estimate it from experience of other cities in the relevant population size category.

The program prints the results as shown in the samples below:

Paratransit

```
Fare charged  $              .8499999     per trip
Lift equipped  Subscription necessary  Many to many

For population              692732
For vehicle capital cost in $                 25000
For annual vehicle operating hours            2000
For vehicle hourly operating cost in $        23

Population density is                         3681.629
Annual trips per capita are                   .2216059
Total annual trips are                        153513.5
Productivity (trips per vehicle hour) is      2.558384
Fleet size is                                 38
Fleet cost is                                 950000
Operating cost per trip is                    8.990051
Total annual operating cost is                1380094
    of which   130486.5      is paid by the user
Total annual budget is                        1570094
```

User-side

```
User side subsidy system
Fare charged   10           % of standard fare
Lift equipped  Subscription necessary  Many to many

For population              692732
For average taxi fare in $  5.6

Annual trips per capita are                   .2216059
Total annual trips are                        153513.5
Total annual operating cost is                859675.4
    of which   85967.54      is paid by the user
Total annual budget is                        859675.4
```

SPECIAL NEEDS IN PUBLIC TRANSPORTATION

SOME SURVEY RESULTS

by

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SPECIAL NEEDS IN PUBLIC TRANSPORTATION:

SOME SURVEY RESULTS

1.0 Background

Over the past decade, a combination of events have caused a reappraisal of transportation legislation relating to the disabled in Canada. External events include the enactment of the Rehabilitation Act by the United States Congress in 1973, and the United Nations declaration of 1981 as the Year of the Disabled, which focused world attention on the needs and rights of the disabled. Within Canada there have been several government-sponsored open meetings canvassing opinions and suggestions relating to the needs of the disabled. Other factors have been the passing of the Charter of Rights and Freedoms in 1982, and amendments to the Canadian Human Rights Act in 1983 which further strengthened the rights of the disabled, and which introduced the concepts of accessibility standards and adaptibility plans.

The Canadian Transport Commission is involved in the development of accessibility standards for transportation modes under federal jurisdiction: namely, air, rail and, to some extent, inter-city bus.

In developing standards, it is important that one understand the current problems and barriers to full access, and know the numbers of people who might benefit from proposed changes, in order that responsible decisions can be made which will balance different needs and solutions, together with their costs and the benefits to be gained. While some estimates exist concerning the numbers of people with various kinds of transportation-related disabilities, these have not been particularly satisfactory for our purposes. Some have been based on American statistics, or were drawn from small regions of Canada, or covered only urban centres, or asked questions which are not relevant to transportation disabilities. For example, the Data Base Study for the Identification and Quantification of Transportation Handicapped Persons in Canada (1) was based on U.S. survey results from urban areas obtained by the Urban Mass Transportation Administration (UMTA) of the U.S. Department of Transportation. Another study, The Sociodemographic and Need Related Characteristics of the Physically Handicapped in Ontario (2) surveyed only the Province of Ontario. The Canada Health Survey (3) was nationwide, but focused on questions concerning the ability to do certain activities, and the activities covered unfortunately do not allow for accurate translation into statistics on transportation related disabilities. A fourth source, the Data Handbook on Disabled Persons in Canada (4) combines results from the Canada Health Survey with other sources, including (1) and (2). In addition, none looked at the types of transportation problems encountered by disabled persons using intercity modes of transport.

Thus a survey entitled "Special Needs in Public Transportation" was undertaken in August 1983, sponsored jointly by the Canadian Transport Commission and Statistics Canada, with the goals of determining:

1. The size of the handicapped community, available by various types of transportation disability.
2. The forms of assistance required by transportation disabled persons when travelling by air, rail, and intercity bus.
3. The problems and barriers they encounter when travelling.

2.0 Survey Methodology

The Special Needs in Public Transportation Survey was conducted in August 1983 as a supplement to the Labour Force Survey (LFS). The LFS samples residents of Canada 15 years of age and over from the 10 provinces. It excludes those living in the Yukon and Northwest Territories, Indian Reserves and Crown Lands, inmates of institutions, and members of the Armed Forces, who together total about 2% of the total population of Canada. A detailed description of the methodology for the LFS can be found in the Statistics Canada Catalogue 71-526 (Occasional) entitled "Methodology of the Canadian Labour Force Survey", 1976.

The omissions are unfortunate as they leave out several groups of special interest -- children, natives, those of the Far North, and in particular those living in institutions where one might expect, a priori, a significant proportion of the disabled to live. However, the LFS is such a fast, efficient, and economical vehicle for collecting data that it was felt its advantages more than outweighed its disadvantages.

A copy of the six survey questions (renumbered here for convenience), that were attached to the LFS, appear in Figure 2.1. These were attached to two segments or rotations groups out of the six which comprise the full LFS. This resulted in a sample size of approximately 18,000 households or 39,000 individuals.

The numbers presented in Sections 3 and 4 are projections of the survey results to the Canadian "target" population; that is, those 15 and over living in the 10 provinces, excluding those on reserves, crown lands, institutions, and the armed forces. It should be noted that

Figure 2.1

1. DO YOU HAVE ANY PHYSICAL CONDITION OR HEALTH PROBLEM WHICH MAKES IT DIFFICULT FOR YOU TO TRAVEL WITHOUT SOME FORM OF ASSISTANCE OR AID? *(e.g., wheelchair, cane, attendant assistance)*

Yes 1 ○ No 2 ○ END

2 IS YOUR PHYSICAL CONDITION OR HEALTH PROBLEM RELATED TO ANY OF THE FOLLOWING?

	Yes	No
Seeing	1 ○	2 ○
Hearing	3 ○	4 ○
Mobility	5 ○	6 ○
Other *(specify in NOTES)*	7 ○	8 ○

3 ARE YOU PREVENTED FROM USING ANY OF THESE FORMS OF TRANSPORTATION BECAUSE OF YOUR PHYSICAL CONDITION OR HEALTH PROBLEM?

	Yes		No
Airplane	1 ○	If all 'Yes' END	2 ○
Train	3 ○		4 ○
Bus excluding city bus	5 ○		6 ○

4 SINCE THE ONSET OF YOUR PHYSICAL CONDITION OR HEALTH PROBLEM, HAVE YOU USED ANY OF THE FOLLOWING FORMS OF TRANSPORTATION? *(Mark all that apply)*

- Airplane 1 ○ } Go to 14
- Train 2 ○ } Go to 14
- Bus excluding city bus 3 ○ } Go to 14
- None of the above 4 ○ END

5 WHEN TRAVELLING ON AN AIRPLANE, TRAIN OR BUS, DID YOU ENCOUNTER DIFFICULTIES WITH ANY OF THE FOLLOWING? *(Mark all that apply)*

- Hearing announcements 01 ○
- Seeing signs, notices or announcements 02 ○
- Going up and down stairs/escalators 03 ○
- Moving about the terminal 04 ○
- Boarding/disembarking 05 ○
- Seating on board 06 ○
- Washroom facilities 07 ○
- Transporting wheelchair 08 ○
- Transportation staff 09 ○
- Carrier rules and regulations 10 ○
- Other *(specify in NOTES)* 11 ○
- None of the above 12 ○

6 WHICH OF THE FOLLOWING AIDS OR ASSISTANCE HAVE YOU USED WHEN TRAVELLING ON AN AIRPLANE, TRAIN OR BUS? *(Mark all that apply)*

- Wheelchair owned by you 01 ○
- Wheelchair provided by terminal or carrier 02 ○
- Special assistance provided by staff 03 ○
- Personal attendant accompanying you 04 ○
- Manual or mechanical lift to board or disembark 05 ○
- White cane 06 ○
- Guide dog 07 ○
- Walking aid *(cane, walker or crutches)* 08 ○
- Other *(specify in NOTES)* 09 ○
- None of the above 10 ○

these numbers are only estimates of the true number (or fraction, or percentage, as the case may be). It is possible, using statistical methods to estimate the level of uncertainty surrounding each number, in the sense that intervals or bounds can be determined around each value within which one can be sure, at some level of confidence, that the true value falls.

Statistics Canada guidelines require that estimates or values may only be presented in an unqualified fashion when the sample coefficient of variation (the standard deviation of the estimate divided by the estimate itself) of the estimate is less than 16.6%. If the coefficient of variation is between 16.6% and 25% the estimate may be presented if a warning is included, and if the coefficient of variation is greater than 25% then the number may not be released at all. These guidelines are observed in this paper, which uses an * to denote a value with a coefficient of variation between 16.6% and 25% and ** to replace a value with a coefficient of variation greater than 25%.

3.0 Survey Results: Types and Incidences of Disabilities

Question 1.

DO YOU HAVE ANY PHYSICAL CONDITION OR HEALTH PROBLEM WHICH MAKES IT DIFFICULT FOR YOU TO TRAVEL WITHOUT SOME FORM OF ASSISTANCE OR AID?
(e.g., wheelchair,cane,attendant assistance)

Yes 533,000 **No** 18,314,000

Out of a total target population of 18,848,000 people, over half a million, or 2.8%, indicated they had some physical condition or health problem which made travel difficult without some form of assistance or aid. This percentage is lower than most percentage figures on the proportion of disabled persons coming from other sources (see Section 7.0). This result was to be expected, as the Special Needs Survey is interested in transportation related disabilities only, and in addition requires a respondent to admit to a limiting physical condition or health problem, and it is well known by investigators doing disability statistics research that respondents to surveys are often reluctant to admit to any kind of limiting disability, or handicap.

Because of the known problems when dealing with self-reported disability data, it would be wisest to treat the Special Needs incidence figures as lower bounds on the true proportion of transportation disabled individuals among the target population. That is, there may well be more disabled people, but it is unlikely there are any fewer.

Question 2.

IS YOUR PHYSICAL CONDITION OR HEALTH PROBLEM RELATED TO ANY OF THE FOLLOWING?

	Yes	No	Not Stated	Total
Seeing......................	108,000	247,000	179,000	533,000
Hearing.....................	87,000	250,000	197,000	533,000
Mobility....................	379,000	69,000	85,000	533,000
Other(specify in NOTES).....	122,000	202,000	209,000	533,000

Of those who reported a problem with transportation in question 1, 71.1% indicated it was a mobility related problem, 20.2% indicated a seeing problem, and 16.3% indicated a hearing problem.

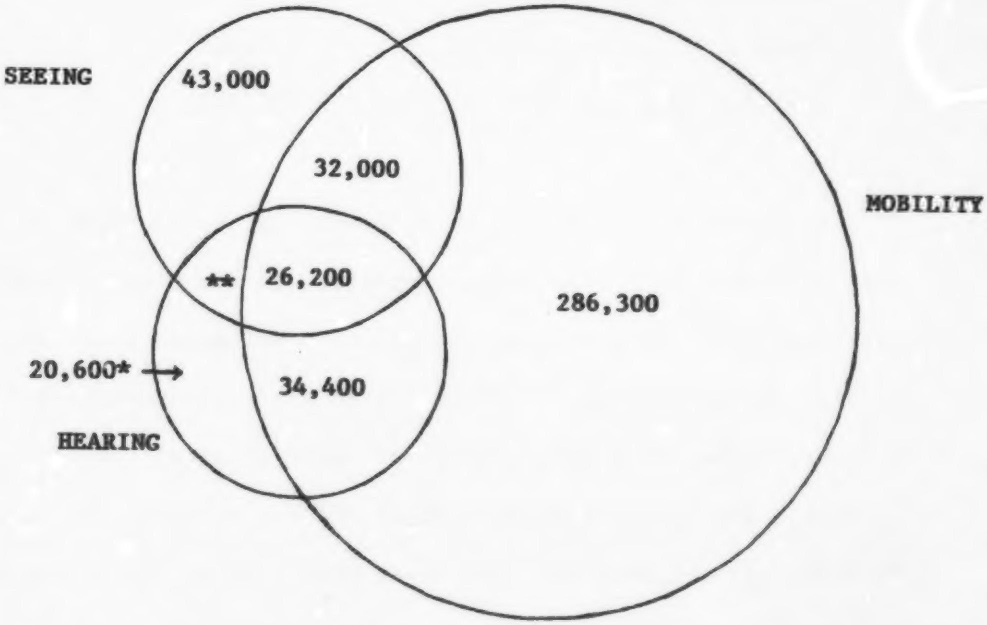
Reanalyzing in terms of percentages gives:

TYPE OF DISABILITY REPORTED	PERCENTAGE OF TOTAL TARGET POPULATION	PERCENTAGE OF DISABLED POPULATION
Seeing	.57%	20.2%
Hearing	.46%	16.3%
Mobility	2.01%	71.1%
Other	.65%	22.9%

The most common disability is one of mobility. This is reported more than three times as often as any other.

The "other" category is large, but is made up of a great many different kinds of disabilities. The two largest subgroups in this category are mental disabilities and heart/circulatory problems, followed by major diseases which restrict ones ability to travel, arthritis, and respiratory problems, to name the larger subgroups. No subgroup is more than twenty per cent of the total "other" group; consequently all are small relatively to the three major disability groups.

The number of people indicating more than one transportation related disability is available for the three major groups, and are represented below.



These statistics show higher incidences of multiple disabilities than could be intuitively expected. For example, more than 70% of those with a hearing problem also have a sight or mobility (or both) problem. About 60% of those with a seeing problem also have a hearing or mobility problem.

* Coefficient of Variation greater than 16.6%.

** Coefficient of Variation greater than 25%.

4.0 Survey Results - Transportation Difficulties and Needs of The Disabled

Question 3.

ARE YOU PREVENTED FROM USING ANY OF THESE FORMS OF TRANSPORTATION BECAUSE OF YOUR PHYSICAL CONDITION OR HEALTH PROBLEM?

	Yes	**No**
Airplane......................	210,000	282,000
Train.........................	207,000	282,000
Bus excluding city bus........	221,000	270,000

Thirty-nine per cent of those answering yes to question one indicated they were prevented from using airplanes, thirty-nine per cent were prevented from using trains, and 41% were prevented from using buses. In all, 36% or 190,000 people indicated they were prevented from using all three modes of travel because of their physical condition or health problem. Thirty-Six thousand people did not reply to this question. This may reflect many who have never attempted to use any mode, and who thus do not know if they are prevented or not.

As 190,000 people indicated in question 3 that they were prevented from using all modes of transportation, their interview ended, and only 343,000 people were asked question 4. Of these, 30% have travelled by air, 12% by train, and 24% by intercity bus, while 52% indicated that they had used none of these and 23,000 people or 7% did not respond to question 4.

Question 4.

SINCE THE ONSET OF YOUR PHYSICAL CONDITION OR HEALTH PROBLEM, HAVE YOU USED ANY OF THE FOLLOWING FORMS OF TRANSPORTATION? (mark all that apply)

Airplane........................	102,000
Train...........................	42,000
Bus excluding city bus..........	81,000
None of the above...............	177,000

A total of 140,000 people indicated in question 4 that they had used at least one mode of intercity transportation. Only these people were subsequently asked to respond to questions 5 and 6.

Question 5.

WHEN TRAVELLING ON AN AIRPLANE, TRAIN OR BUS, DID YOU ENCOUNTER DIFFICULTIES WITH ANY OF THE FOLLOWING? (mark all that apply)

Hearing announcements...................................	21,000*
Seeing signs, notices or announcements..................	25,000
Going up and down stairs/escalators.....................	89,000
Moving about the terminal...............................	66,000
Boarding/disembarking...................................	78,000
Seating on board..	23,000*
Washroom facilities.....................................	24,000*
Transporting wheelchair.................................	**
Transportation staff....................................	13,000*
Carrier rules and regulations...........................	
Other (specify in NOTES)................................	**
None of the above.......................................	**

Of those indicating they have travelled (140,000), by far the most frequently encountered difficulties or barriers were stairs and escalators, (65%) boarding and disembarking (56%), and moving about terminals (47%).

Question 6.

WHICH OF THE FOLLOWING AIDS OR ASSISTANCE HAVE YOU USED WHEN TRAVELLING ON AN AIRPLANE, TRAIN OR BUS?(Mark all that apply)

Wheelchair owned by you.................................	17,000*
Wheelchair provided by terminal or carrier..............	31,000
Special assistance provided by staff....................	58,000
Personal attendant accompanying you.....................	63,000
Manual or mechanical lift to board or disembark.........	15,000*
White cane..	**
Guide dog...	**
Walking aid(cane, walker or crutches)...................	57,000
Other(specify in NOTES).................................	**
None of the above.......................................	26,000

The most common form of assistance is to have a personal attendant, followed by having special assistance from staff. Many travellers also use a walking aid of some kind or use a carrier or terminal provided wheelchair.

5.0 Survey Results: Cross Tabulations

The simple tabulations of results from the survey are interesting in themselves, but of more use, perhaps, are such tabulations broken down by type of disability and/or mode of travel.

Table 5.1 lists the percentages of people within each major disability group who are (or perceive themselves to be) prevented from using each mode of travel.

Table 5.1

	Prevented from Using			
Disability	Air	Train	Intercity Bus	All Three Modes
Seeing	46%	44%	45%	42%
Hearing	49%	44%	48%	44%
Mobility	39%	40%	44%	36%

It would seem that the mobility impaired as a group consider themselves to be less restricted in their ability to use the various modes of public transportation than the other two groups. It should be noted that this conclusion is not statistically significant, because of the variability of these estimates. Similarly, from Table 5.2 below, which looks at actual travel by disability group, one might conclude, at least for air and bus modes, that the mobility impaired travel proportionately less than the other two groups. This again is not statistically significant.

Table 5.2

Disability	Percentage using Each Mode Air	Train	Intercity Bus
Seeing	16%*	**	14%*
Hearing	16%*	**	14%*
Mobility	15%	5%*	11%

The major difficulties encountered by those belonging to each disability group who have travelled by a particular mode appear in Table 5.3. The percentages reflect the number of people indicating that a particular difficulty was encountered, out of the total number who travelled by the indicated mode and who belonged to each disability group.

Table 5.3

	Mode Used Air	Train	Intercity Bus
Seeing Disability			
- Seeing Signs	63%	80%	83%
- Stairs	71%	65%	53%*
- Moving about Terminal	58%*	**	**
- Boarding	60%	56%*	**
Hearing Disability			
- Hearing Announcements	77%	83%	77%
- Stairs	49%*	**	**
- Moving about Terminal	45%*	**	**
- Boarding	52%*	**	56%*
Mobility Disability			
- Stairs	72%	91%	75%
- Moving about Terminal	58%	64%	55%
- Boarding	63%	71%	69%
- Seating	18%	**	19%*
- Washrooms	25%	33%*	21%*

As one would expect, those with seeing disabilities had trouble with seeing signs, and those with hearing disabilities had trouble hearing announcements. Mobility related difficulties are greatest for those with mobility difficulties. However, both those with seeing disabilities and hearing disabilities experience difficulties with mobility-related barriers such as stairs, moving about a terminal, and boarding. Such problems do not seem as common for the hearing impaired as for the sight impaired although it is still large. This result may reflect the large number of respondents who are mobility impaired, and also have a seeing or hearing disability.

The major forms of assistance or aids used by those belonging to each disability group who have travelled by a particular mode are listed in Table 5.4.

Table 5.4

	Mode Used		
	Air	Train	Intercity Bus
Seeing Disability			
- Special Assistance	49%*	**	44%*
- Personal Attendant	46%*	**	42%*
Hearing Disability			
- Special Assistance	55%*	**	**
- Personal Attendant	51%*	**	57%*
Mobility Disability			
- Wheelchair owned	16%*	**	**
- Wheelchair provided	32%	**	**
- Special Assistance	48%	44%*	44%
- Personal Attendant	46%	56%	48%
- Walking Aid	45%	52%	53%

Personal attendants, or special assistance from carrier personnel are the most frequently used aid in travelling for all three disability groups, for all modes of travel.

It should be noted that travelling with a personal attendant does not mean that the attendant was required for medical reasons, on the insistance of the carrier, or for any other reason, except that the respondent, in replying to the question, indicated that they had a personal attendant accompany them on such trips.

6.0 Regional Statistics

Disability statistics are available from the Special Needs Survey for five regions of Canada:

1. British Columbia
2. Prairies (Alberta, Saskatchewan, Manitoba)
3. Ontario
4. Quebec
5. Maritimes (New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland)

Regional incidences of transportation disabilities appear in Table 6.1. These range from a low of 2.3% in Quebec to a high of 3.5% in British Columbia, indicating the existence of regional differences.

Table 6.1

Regional Statistics

Region	Total Population ('000)	Disabled Population ('000)	Disabled Percentage
British Columbia	2136	75	3.5%
Prairies	3196	84	2.6%
Ontario	6823	205	3.0%
Quebec	4977	114	2.3%
Maritimes	1715	55	3.2%
Canada	18848	533	2.8%

There also seem to be differences in the incidences of transportation disabilities between urban and rural areas, as shown in Table 6.2.

Table 6.2

Percentage Transportation Disabled

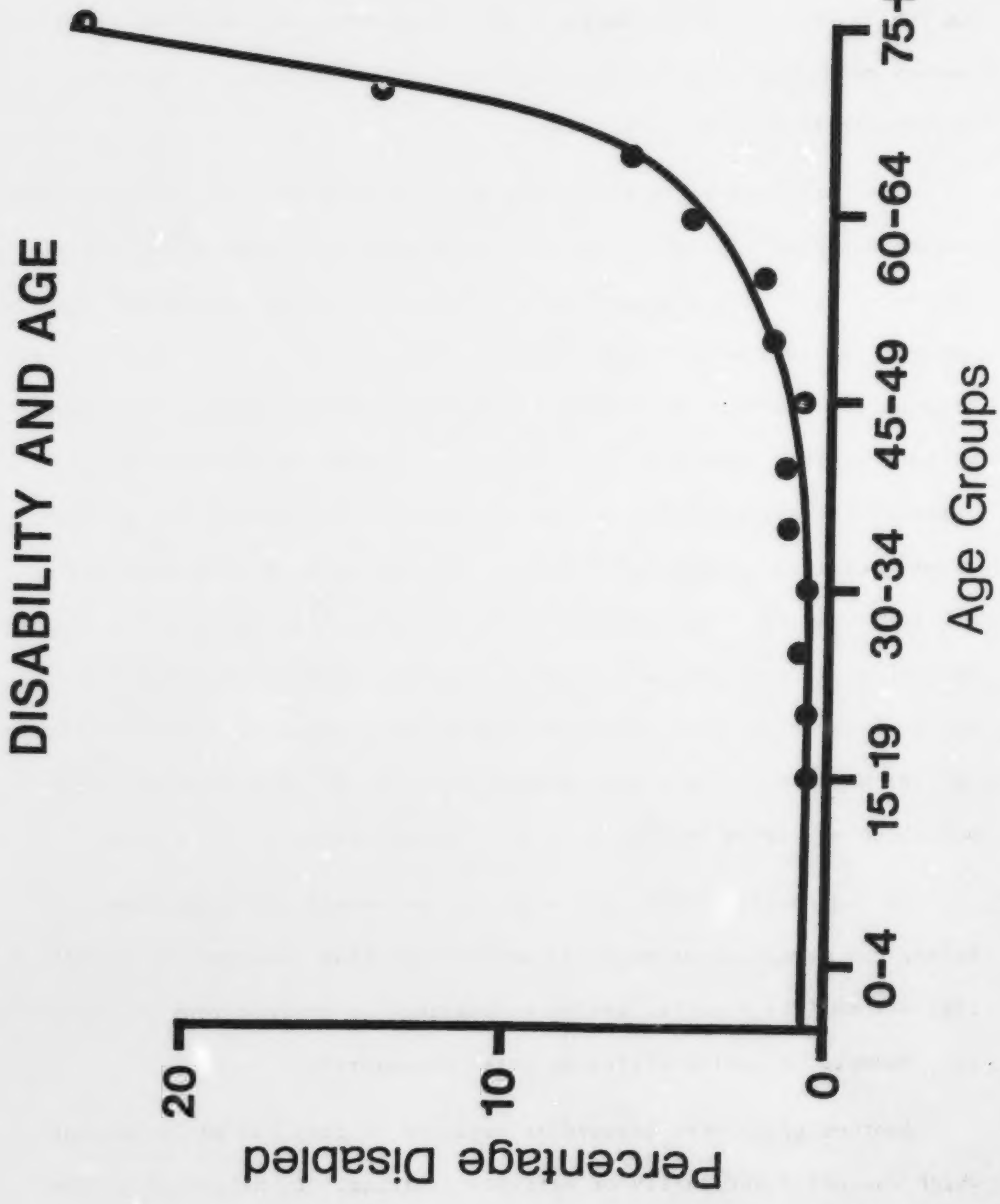
Region	Urban	Rural
British Columbia	3.64	3.13*
Prairies	2.57	2.80
Ontario	3.03	2.90*
Quebec	2.44	1.93*
Maritimes	3.38	3.05
Canada	2.90	2.67

While differences are not significant at regional levels, they are on a Canada wide basis.

In addition, it is apparent that age is very closely related to the incidence of disability, as can be seen from Figure 6.1. In fact, the strength of the age relationship suggested that it may in fact be the explanation for the regional and urban/rural differences that were observed.

This hypothesis was partially borne out in a preliminary analysis of the survey results. Some approximate tests of significance were performed which showed an extremely strong age effect, and inconclusive findings regarding rural/urban and regional differences.

FIGURE 6.1


DISABILITY AND AGE
Percentage Disabled
20
10
0
0-4
15-19
30-34
45-49
60-64
75+
Age Groups

7.0 Comparison with Other Data Sources

There are problems in comparing results from the Special Needs in Public Transportation Survey (SNPT) with other sources, due to differing survey methodologies, scopes, questions, and definitions. However, an attempt is made in Table 7.1.

The Data Base Study (1) produced an estimate of 4.97% as the percentage of the Canadian population who are transportation handicapped, where the definition of a transportation handicapped person is one who experiences general problems with vision, hearing, mobility etc., and who perceives that he/she has more difficulty using public transportation than people without his/her problems. Note that this percentage includes those experiencing difficulties with all forms of urban transit (city buses, trams, subways), so one could expect this estimate to be higher than the SNPT results. In addition, there are reasons to believe the Canadian incidence of transportation disabilities may be lower than the U.S. incidence due to such things as a different health care system and the U.S. involvement in Viet Nam, which could not be quantified in the Data Base Study (1) but which may cause results in (1) to be overestimated for Canada.

In the Ontario Study (2), a person was considered handicapped if he/she had a medical or physical conditional that resulted in functional limitations (for example, seeing or hearing) or restrictions on activities (for example, climbing stairs or doing housework).

Another group were classed as impaired if they had an impairment which was not functionally or activity limiting. In all, 5.4% of the population were estimated to be handicapped, and 4.5% were estimated

Table 7.1

A Comparison of Transportation Handicapped Statistics from Various Studies

Study	Nature of Study	Survey Date	Target Population	Transportation Disabled as a % of Target Population
Data Base (1)	Based on U.S. UMTA Data 16,000 households	1976/7	Urban Centres People 5 years of age and greater	4.97%
Ontario (2)	Survey of Ontario, 15,000 households	1980	Province of Ontario All ages	2.1 - 3.9%
Canada Health (3)	Nationwide 12,000 households	1978/9	Whole population excluding territories, reserves All Ages	2.1 - 9.4%
Canada Mortgage Data Handbook (4)	N/A	N/A	Whole population of Canada	2.9 - 6.9%
Special Needs in Public Transp.	Nationwide 13,000 households	1983	Whole of Canada excluding territories, and reserves. People 15 years of age and older.	2.8%

to be impaired. Unfortunately the activities used to determine if a person was classed as handicapped or merely impaired do not cover many transportation related activities, so that some people who experience transportation problems would have been classed as impaired. However, 39.7% of the handicapped population indicated that they were either unable to use or had difficulty using public transit. Thus at a minimum, one would estimate that 2.1% of the general population were transportation disabled. As a worst case, assuming that 39.7% of the impaired also had difficulty with public transit, gives an upper estimate of 3.9% of the general population being transportation disabled. Public transportation in this survey basically implied urban transit, which again makes direct comparisons difficult. It is interesting to note however that the most commonly reported difficulty, among those who have difficulty, was in getting on and off vehicles. Also of interest is that 46.4% of the handicapped reported some level of difficulty in accessing bus and train stations, and 41.3% reported difficulties accessing airports.

In the Canada Health Survey (3), it was estimated that 9.4% of the population experienced limitation in their major activity (housework, working, or school). Included in this figure were 2.1% who were inactive due to health, or could not pursue their major activity. These bounds are too broad to be of much use in estimating the incidence of transportation disabilities.

A fourth source, the Canada Mortgage and Housing Corporation Study (4), basically uses results from the Canada Health Survey (3), augmented with results from other studies, including (1) and (2). It estimated that 6.9% of the total population experience some form of difficulty in using transportation services. This figure is based on the 11.4%

of the population estimated in (3) to have an activity limitation, including both major and minor activities, and results from (1). The actual derivation of this figure is unclear. In addition, this study estimates that 33.8% of those with major activity limitations, estimated at 9.4% in (3), experience difficulty with mobility. Assuming this group would then be transportation disabled, one then obtains a lower bound of 2.9% of the population that is transportation disabled.

8.0 Conclusion

The major results of the "Special Needs in Public Transportation" Survey are:

1. Mobility disabilities are the most common transportation disability, followed by seeing disabilities, then hearing disabilities.
2. While a large portion of transportation disabled individuals feel they cannot use public forms of transportation because of their disabiities, an even larger group can and do use the various modes of public transportation.
3. Stairs/escalators, moving about a terminal, and boarding are the three most common difficulties encountered by transportation disabled individuals. As was to be expected, those with seeing disabilities also have difficulty seeing signs, notices, and announcements, and those with hearing disabilities have difficulty hearing announcements.
4. The most common form of assistance is to have staff provide special assistance or to travel with a personal attendent. Those with mobility disabilities often use a walking aid or wheelchair; their own or carrier provided.
5. Transportation disabled persons live everywhere. There are no dramatic differences in the incidences of transportation disabilities between regions or urban and rural areas of the country. What differences there are seem to be mainly accounted for by the differences in the age profiles of the regions or areas.
6. The incidence of transportation disabilities increases with age.

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2. The Sociodemographic and Need Related Chracteristics of the Physically Handicapped in Ontario (1981) (unpublished) J.W. Gilbert Associates Ltd. and Levy Coughlin Partnership Inc. Prepared for the Government of Ontario.

3. The Health of Canadian. Report of the Canada Health Survey, (1981) Health and Welfare Canada and Statistics Canada.

4. Data Handbook on Disabled Persons in Canada (1982) Medicus Canada. Prepared for Canada Mortgage and Housing Corporation.

ADAPTATIONS TO STAGE CARRIAGE BUSES
FOR DISABLED AND ELDERLY PEOPLE

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ADAPTATIONS TO STAGE CARRIAGE BUSES FOR DISABLED AND ELDERLY PERSONS

Introduction

1. In the mid-nineteen seventies research commissioned by the Transport and Road Research Laboratory (TRRL) showed that about four million people in the UK had difficulty in using, or were unable to use, the typical buses then in service.[1] A recent survey of elderly people (1982) showed that nine percent of people over 65 were unable to use buses solely because of physical difficulties and a further 16 percent did so only with great difficulty.[2]

The elderly form an increasingly large proportion of the total UK bus users and it is clearly to the advantage of such passengers and operators alike to improve and make easier the use of public service vehicles. The problems faced by these people are many. Climbing steps, both up and down, movement within the bus, reaching a bell push, can all cause problems. Even apparently minor matters of design, such as the location and dimensions of handholds which an able-bodied person would barely notice, can make a considerable difference to the ease of use by the less able-bodied.

Even though the elderly and less able are an important subset of the total bus user population they are still a minority. From the operator's point of view, therefore, any modifications to either bus design or operation have to be made in such a way that they do not work to the disadvantage of the able-bodied majority of passengers.

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[1] Brooks, B M, Ruffell-Smith, H P and Ward, J S. An investigation of Factors effecting the Use of Buses by both Elderly and Ambulant Disabled Persons, British Leyland UK Ltd and TRRL (1974)

[2] General Household Survey (1982)

This paper reports some findings on the effects of simple adaptations to stage carriage buses in the UK.

2. The modifications studied

South Yorkshire Passenger Transport Executive (SYPTE) has introduced two modifications to bus entrances, both intended to make boarding easier for the less able-bodied. These modifications, respectively the split step and the 'kneeling' bus, formed the starting point of the research undertaken by the Centre for Transport Studies, Cranfield Institute of Technology, for TRRL.

The split step configuration is shown in Fig. 1 and is built so that in the rear-ward half of the entry the height from the ground to the first step is reduced from approximately 37cm to 28cm (or about 17cm from a normal height kerb). This half of the entrance then has two further steps each of 16.5cm, while the conventional forward half of the entrance has only one step of just over 24cm.

The kneeling mechanism was developed for single deck Leyland National buses with air suspension and, by exhausting the air from the nearside front bellows, allows that corner of the bus to drop by just over 11cm to give a ground to first step height of 25.5cm. (See Fig. 2).

Earlier an extensive field survey[3] had shown that a significantly higher proportion of elderly, handicapped and encumbered passengers used the lower part of the split step in comparison with the proportion using the equivalent rear-ward half of the straight unmodified step. The split step did not cause any significant changes to average boarding times. The kneeling mechanism had been found to be seldom activated by drivers so no firm conclusions about its value to users could be drawn. Both modifications were cheap to make and neither carried any penalty in continuing maintenance or repair costs.

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[3] Oxley, P R and Benwell, M, The use of buses in Sheffield by elderly and handicapped people. Department of the Environment Department of Transport. TRRL Report No. SR779, Crowthorne 1983, (Transport and Road Research Laboratory).

3. The experimental study

3.1 Objectives

The second stage of the study examined the two modifications in comparison with current standard buses under controlled conditions. This work also considered the effects (on ambulant disabled passengers) of changes in driving regimes. The intention was to provide guidance on the design of buses and to estimate the passenger usage effects which might result from such changes in design and driving regime.

3.2 Methodology

A representative sample of 55 elderly and ambulatory disabled people was drawn from a household survey covering 1750 households in Bedford. The 55 people were categorised by type and severity of disability* and were brought to Cranfield in small groups where they spent a day boarding, alighting and riding in four different buses. One bus (a single deck Leyland National) was fitted with the kneeling mechanism, one (a double deck Leyland Atlantean) had a split step entrance, the other two (double deck Bristol and Olympian) were conventional double deck buses typical of vehicles in service in the UK, and, in particular, in the Bedford area. The passengers were timed boarding, alighting and moving within the buses both individually and in groups and were questioned after each manoevre on each bus to ascertain their views on the ease or difficulty of each action. Measurements were also made of stride distance from a moveable pavement onto the bus step. Finally each group of passengers was taken on a short circuit on the Bristol and Olympian buses with the bus being driven in normal mode over one circuit and then in 'careful' mode in which the bus remained stationary while passengers were moving to or from their seats. (See Plates 1-4).

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* Severity of disability categories were slight, moderate and severe.

3.3 Summary of findings: boarding and alighting

The subjective comparison by the passengers of the ease or difficulty of boarding and alighting is summarised in Table 1.

Table 1

General rating of ease / difficulty with each bus type

		Getting on			Getting off		
		Easy	Neutral	Difficult	Easy	Neutral	Difficult
'Standard' Buses *	Olympian	40 (73%)	9 (16%)	6 (11%)	28 (51%)	14 (25%)	13 (24%)
	Bristol VR	41 (75%)	6 (11%)	8 (15%)	33 (60%)	13 (23%)	9 (16%)
Modified buses	Split step Atlantean	51 (92%)	1 (2%)	3 (6%)	34 (62%)	4 (7%)	27 (31%)
	Kneeling National (Knelt)	50 (91%)	1 (2%)	4 (7%)	22 (40%)	5 (9%)	28 (51%)

* but with some retro-fitting of external stanchions and rails

The passengers showed a clear preference for the two buses with the modified entrances so far as boarding was concerned, but in all cases alighting was found to be relatively more difficult. (Both the modified buses had centre exits which were used by the alighting passengers: that on the split step has three steps down; on the National the exit has two steps - it is only marginally affected by the kneeling action)

When passengers were asked in detail for the reasons for their comments on ease of use, a number of further differences emerged between the four vehicles. Tables 2A and 2B summarise the positive and negative comments made, divided into those concerning the steps and those referring to hand rails.

Tables 2A and 2B

Positive and negative comments on steps and rails by bus type

Getting onto the vehicle

	Comments on steps		Comments on rails		No special comment made
	favourable	adverse	favourable	adverse	
Olympian	5	9	16	3	22
Bristol	9	8	15	3	20
Split step Atlantean	16	7	11	11	10
Kneeling National (knelt)	15	13	9	3	15

Getting off the vehicle

		Comments on steps		Comments on rails		No special comment made
		favourable	adverse	favourable	adverse	
Olympian	front exit	3	15	12	1	24
Bristol VR	front exit	2	17	5	4	27
Split step Atlantean	centre exit	2	9	9	12	23
Kneeling National (Knelt)	centre exit	0	29	8	5	13

Getting on the buses produced favourable response to the steps on the two modified vehicles but this was mitigated to some degree by a general preference for the position and dimensions of the handrails on the two standard vehicles. Alighting showed near unanimity of adverse comments on the steps, particularly so for the National while the Olympian (the more recently designed of the two standard buses) again produced favourable response to its rails.

3.4 Movement within the buses

A number of users commented on the need for rails at about 80 cm continuously or intermittantly along the vehicle. These may only increase confidence, but distinctions were drawn between those buses with luggage rails and those with nothing to hold at this level. The horizontal rail across the front of the bus (from the entrance up to the driver's compartment) was also found helpful.

All users with stiff limbs shared a preference for those layouts where two seats were placed facing each other, forwards and backwards, to provide were avoided as far as possible as were those on a raised plinth. The narrowing effect produced between the seats by the Atlantean's sloping seat backs was disliked, as indeed, was the sloping back itself.

The Atlantean has a slight gradient in the saloon floor from over the front axle back for a distance of 203cm : the rise is only 5cm but this drew adverse comments. So too did any obstructions (eg. seat pedastals) which were close to the aisle. Passengers with sticks or special footwear were nervous about balancing themselves and also about having space around them to move their feet easily.

3.5 Gap width between bus and kerb

A frequent cause of complaint by passengers is that the bus does not draw up close enough to the pavement, thus forcing the passenger to step down into the road before boarding, or off into the road when alighting. A limited amount of testing was undertaken during the experiment using a wooden platform to simulate a pavement and kerb 11cm high (see Plate 2).

The platform was placed by the bus door at a distance starting from 30cm and increasing by 7.5cm intervals up to 60cm. Passengers were asked to board and alight in normal fashion and the distance at which they first stepped down onto the road was recorded. The bus used was the Olympian and 34 respondents took part.

The results are shown in Figure 3 from which it can be seen that all the passengers managed a stride of 30cm and 88 percent could manage 37.5cm for both boarding and alighting. Thereafter the two acts of boarding and alighting begin to diverge with, for a given distance, fewer people able to get off without stepping down onto the road.

The stride distance was considered in relation to the three impairment categories (see Table 3) which showed that over 90 percent of those with a slight impairment could manage a boarding stride of 45cm compared with 78 percent of the moderate and 58 percent of the severe categories. The alighting pattern was more confused. Here the moderate category were less well able to manage the increasing distances than either the severe or slight categories.

Table 3

Stride distance by impairment category:

percent of passengers able to stride given distance

(distance in centimetres)

	Boarding			Alighting		
	30 or less	37.5 - 45	Over 45	30 or less	37.5 - 45	Over 45
Severe	25	25	50	17	33	50
Moderate	11	56	33	22	67	11
Slight	-	38	62	-	61	39

Examination of the performance by health category showed that the arthritic group had the severest problems both in boarding and alighting, followed by those people with other leg and back problems. Those people with respiratory and heart conditions and with multiple problems were generally more able to stride longer distances both on and off the bus.

Very limited comparative testing using the lower step of the Atlantean entrance suggested that the reduced step height increases potential stride distance, particularly when alighting.

3.6 Boarding and alighting times

Individual passengers were timed boarding and alighting from the four bus types with the boarding manoevre being divided into two sections (from kerb to first step, from first step to past driver) and alighting treated as one manoevre from top of steps to both feet on kerb.

Comparison of boarding times showed that overall the two standard buses produced the faster times. To some extent this was probably due to unfamiliarity with the modified buses since the earlier survey work in Sheffield had not shown any significant change in boarding times due to the split step configuration. If the times are analysed by reference to level of impairment quite noticeable differences do appear, as shown in Table 4.

Table 4

Average individual boarding times by impairment level

Boarding from kerb to past driver.

Impairment	Bus type : average boarding times in seconds							
	Olympian		Bristol VR		Split step Atlantean		Knelt National	
	Men	Women	Men	Women	Men	Women	Men	Women
Severe (M4,F8)	7.2	9.7	6.6	9.3	8.4	8.6	7.2	9.5
Moderate (M4,F8)	4.7	5.3	3.8	5.0	4.7	5.3	5.0	5.4
Slight (M5,F11)	3.1	3.4	3.1	3.5	3.2	3.7	3.7	3.3

There are some evident differences between the male and female passengers. In the severe category the split step bus produced the fastest times for the females, but the slowest for males. In the second category (moderate) the Bristol VR showed the fastest times for both males and females, while in the last category (slight) the Bristol VR and Olympian produce the same best time for males, but the knelt National was the fastest for females in this group.

Obviously, the figures conceal considerable variations, particularly among the more acutely impaired people. Taking those people used in the above table, their boarding times onto the Olympian were:-

Severe	from	4	to	14	seconds
Moderate	from	3	to	7	seconds
Slight	from	2	to	4	seconds

Alighting times showed a similar range by impairment category with the two centre exit buses on average producing the longer times.

3.7 Simulated journeys

Circuits were made in two modes as follows:-

(i) Passengers allowed to board and sit and alight while the bus was stationary and the driver instructed to 'drive gently' around the circuit (described as 'wait' circuits).

(ii) Passengers board and alight in the normal manner; that is with the bus starting when the last passenger in the queue had passed the driver and passengers rising from their seats before the bus stopped at the point at which they were to alight. On the circuit the driver was instructed to 'drive normally'. (Described as 'normal' circuits).

The average increase in wheel stop time when the bus remained at the stop until the last passenger was seated over 'normal' operation was 45 percent (range +23% to +78%). Stop times when passengers alighted showed a much smaller increase over 'normal' operation, the average increase being approximately 2 percent (range -12% to +20%).

Although limited in scale the results from this part of the study suggested that the time penalty for allowing ambulatory disabled passengers to reach a seat before the bus moves off and not to have to get up before it stops might not be substantial. Further fieldwork was therefore carried out to relate the experimental findings to actual bus operation.

The critical time from the operator's point of view is the time the passenger takes to get from the driver to a seat. Where the bus is one man operated the bus will not normally move off until the driver has taken the last fare or looked at the passenger's pass. Even with crew operated buses the last passenger to board is usually level with the driver's compartment by the time the driver has closed the door and started to move the bus. The times for start of bus from last passenger past driver are shown in Table 5, from which it can be seen that in normal operation this time is typically two to four seconds: for the ambulant disabled (in the experimental study) the time taken to get from past the driver to a seat was eight to nine seconds.

Table 5

Average time (seconds) from past driver to a seat or wheelstart

Observed category	Average Time (seconds)	Mode (seconds)	Action Measured
Ambulatory))experiment Disabled)	8.8	7.8	Past driver to seat
OMO Singe Deck	4.5	3.6	last passenger past driver to wheelstart
OMC Double Deck	2.9	1.2	
Crew Operation	2.4	1.2	

On modal values the difference is larger, since the distribution of times for all types of operation tend to have a fairly lengthy tail. The over-riding feature of the figures, however, is that they are all small.

The other part of the use of buses which causes problems for the ambulatory disabled is that of alighting; specifically getting up and moving towards the exit before the bus has stopped. Because of the limits imposed by time and resources the detailed measurement of alighting times was not possible, but the data obtained does, none the less, give some guidance on the effects which changes in operation might have.

Alighting in comparison with boarding is a much less important constituent of total bus running time. If net alighting time is defined as those occasions when either no one is boarding or when people are boarding, but those who are alighting take longer, net alighting time only amounts to three to four percent of total running time.

Using the observed incidence of ambulatory handicapped passengers in bus queues, together with the extra time needed to allow them to get to and from their seats while the bus was stationary, it was calculated that the net addition to total bus running time would only be of the order of one percent. To put this figure in context, recovery time is normally allowed for as about five per cent of running time.

4. Conclusions

4.1 Operational practice

The most important conclusion reached on operational matters is probably that relating to the effect of allowing disabled passengers to move to and from their seat while the bus remains stationary.

It is concluded that to do this for boarding passengers would add on a little over one percent to the running time of the bus. The evidence for the effects of allowing disabled passengers to remain in their seats until the bus stops is less clear, but appears to be operationally insignificant.

Although the various entrance step configurations produced different responses form the participants, with a general liking for the split step and the knelt National, neither the experimental work nor the Sheffield survey showed any significant difference in boarding times between these and the conventional buses. Notwithstanding this general conclusion the experiment suggested that the modified steps help speed the entry of the most severely affected passengers.

All of the participants in the experiment were able to step direct between the bus and the kerb when the distance was 30cm. At 37.5cm 90 percent were able to step direct : over this distance a significant proportion of the disabled had to step down onto the road. The proximity of the bus to the kerb for boarding and alighting is probably more important in terms of the willingness of the disabled to use the bus rather than in the time taken to board and alight.

4.2 Design

For the ambulatory disabled there appears to be a break point in step height at approximately 20cm. Above this figure criticisms of height were made by at least some of the participants : none was recorded at less than this.

Fairly even height of steps is regarded favourably (eg. as on the Olympian) as against the unequal proportions of the Bristol VR entrance.

A shallow depth of tread causes problems for some disabled people : a width of 35cm is suggested as an acceptable minimum.

White nosing to the steps is an obvious help to the partially sighted, but this should be flush with the step. Even a very minor protrusion on the step riser can catch the toe of a disabled person as he pulls his foot up to reach the next tread.

Handrail and stanchion diameters should not be less than 3cm (thus confirming the earlier British Leyland TRRL study). Oval shaped rails with 3cm as a maximum diameter also appear to be acceptable.

Handrails on doors, which move a little when any pressure is put on them, were disliked. The external fixed handrails on the Bristol VR were clearly regarded as very helpful, though it is recognised that for other operational and safety reasons, this type of rail is not considered satisfactory by bus operators.

Centre rails or stanchions should be as near as feasible to the front nose on the bottom step. The centre stanchion on the Leyland National, 32cm from the nose of the bottom step was considered to be out of reach (or at least awkward to reach) for some people. That on the split step Atlantean (14cm in) was liked.

There should be a horizontal handrail across the front of the bus from the step well to the driver's compartment, ideally at 80 to 90cm above the saloon floor.

The allocation of the front pair of seats for disabled people makes operational sense since it reduces in-bus movement time. The placing of the front off or near side pair of seats facing backwards allows more room and comfort for some types of disabled people, particularly those who have leg problems and find it difficult to bend their legs.

At least the seats allocated for the disabled should have the bell pushes accessible to people when they are sitting down.

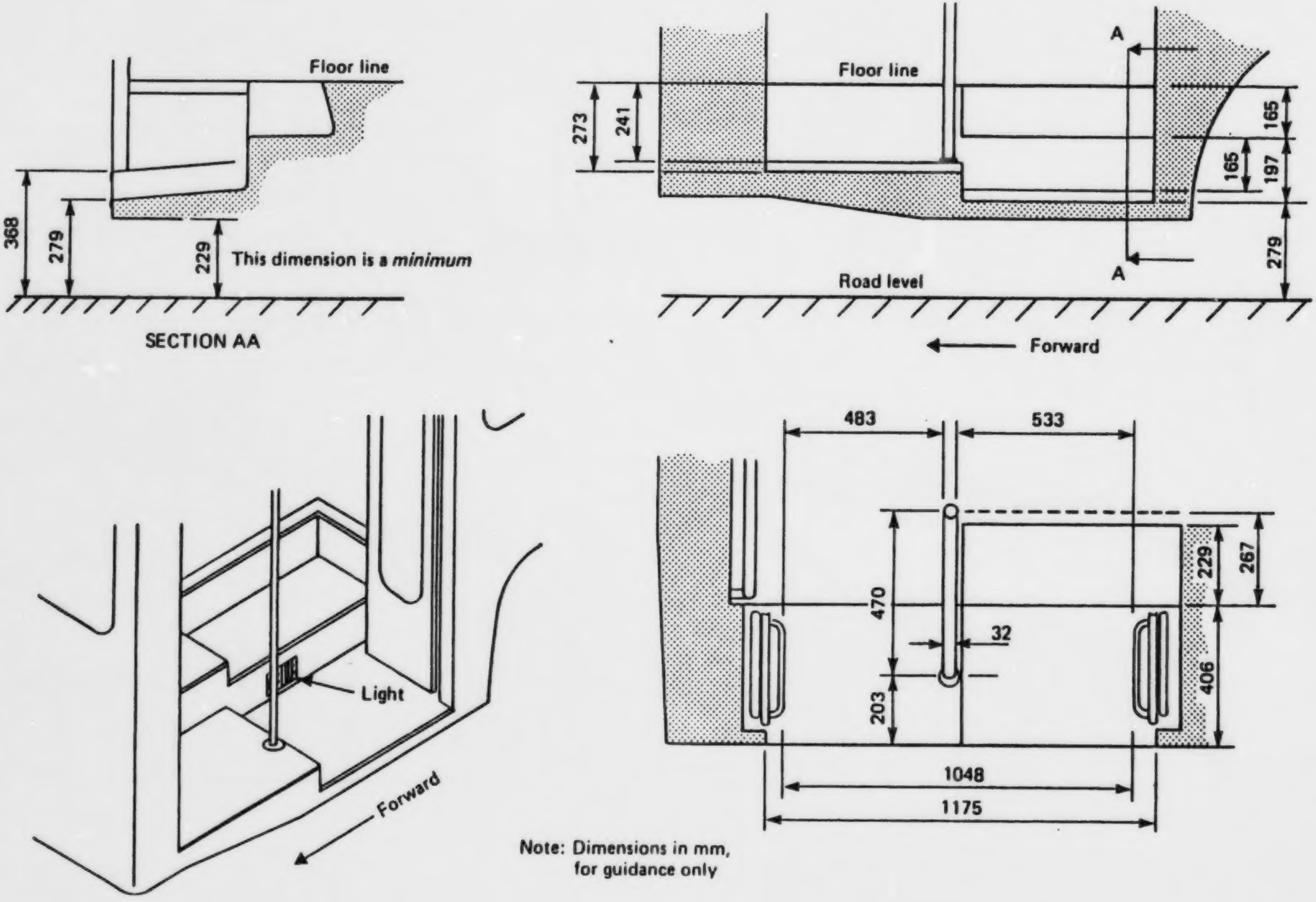
4.3 Patronage implications

Because the participants in the 'experiment' were drawn from a random sample of households, and were asked certain questions comparable to those in a much larger National survey of households in the UK (the General Household Survey) it is possible to make aggregate estimates on the basis of these small numbers.

It was assumed, on the basis of study of their current tripmaking and opinion survey responses, that the population of ambulatory handicapped could be divided into three groups on the basis of their likely response to the changes in bus design being tested. These were:

		Percentage of Total National Population Represented
(i)	Those who would feel less discomfort but would not change their current use of buses.	0.7%
(ii)	Those currently using buses with difficulty and making less trips than they wish. These would increase their tripmaking with design changes.	1.8%
(iii)	Those currently not using the bus, but who *would* use with improved entrance/exit design. (As in the experiment)	0.5%

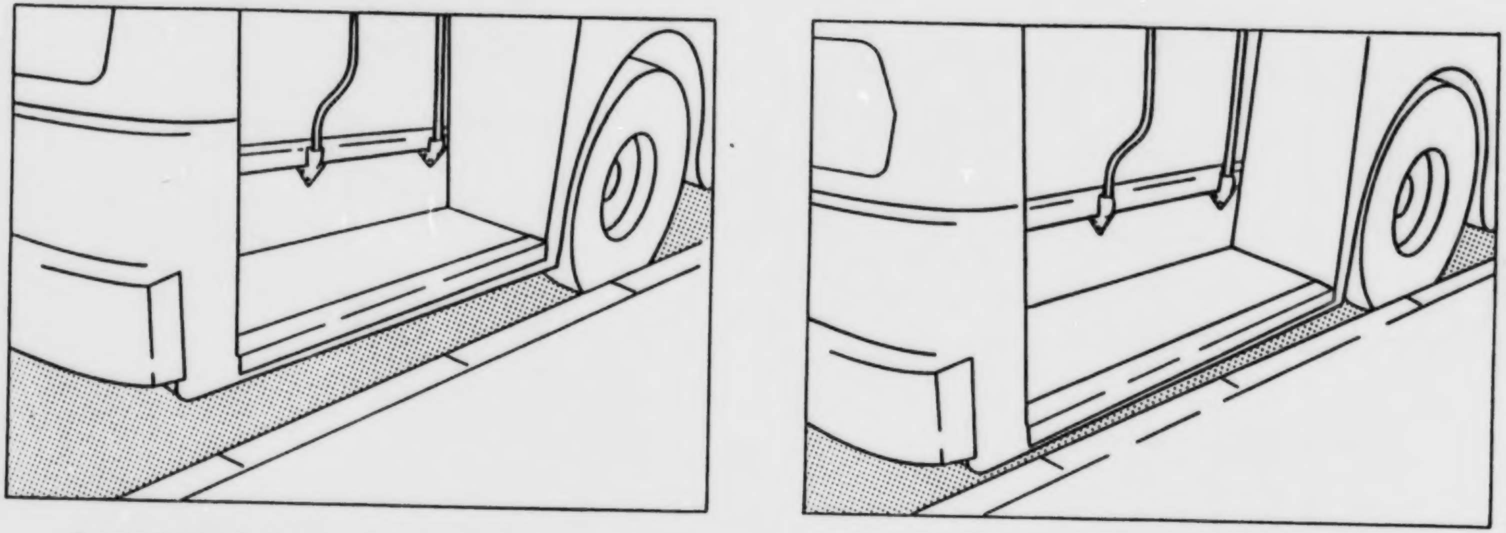
Thus categories (ii) and (iii), contain about 2.3% of the national population - some 1.2m people in the case of the UK. There is a significant commercial gain possible if these people could be persuaded to make just one or two trips more per person per week.


Floor line
368
279
229
This dimension is a *minimum*
SECTION AA
Floor line
273
241
A
A
165
165
197
279
Road level
Forward
483
533
470
32
203
229
267
406
1048
1175
Light
Forward

Note: Dimensions in mm,
for guidance only

Based on drawings by SYPTE

Fig. 1 Layout of the split step entrance



In normal operating position, height to step from ground is 14.5 inches, and from kerb approximately 8 inches

In 'kneeling'position, height to step from ground is reduced to 10 inches, and from kerb only 3.5 inches

Based on drawings by SYPTE

Fig. 2 The kneeling National entrance

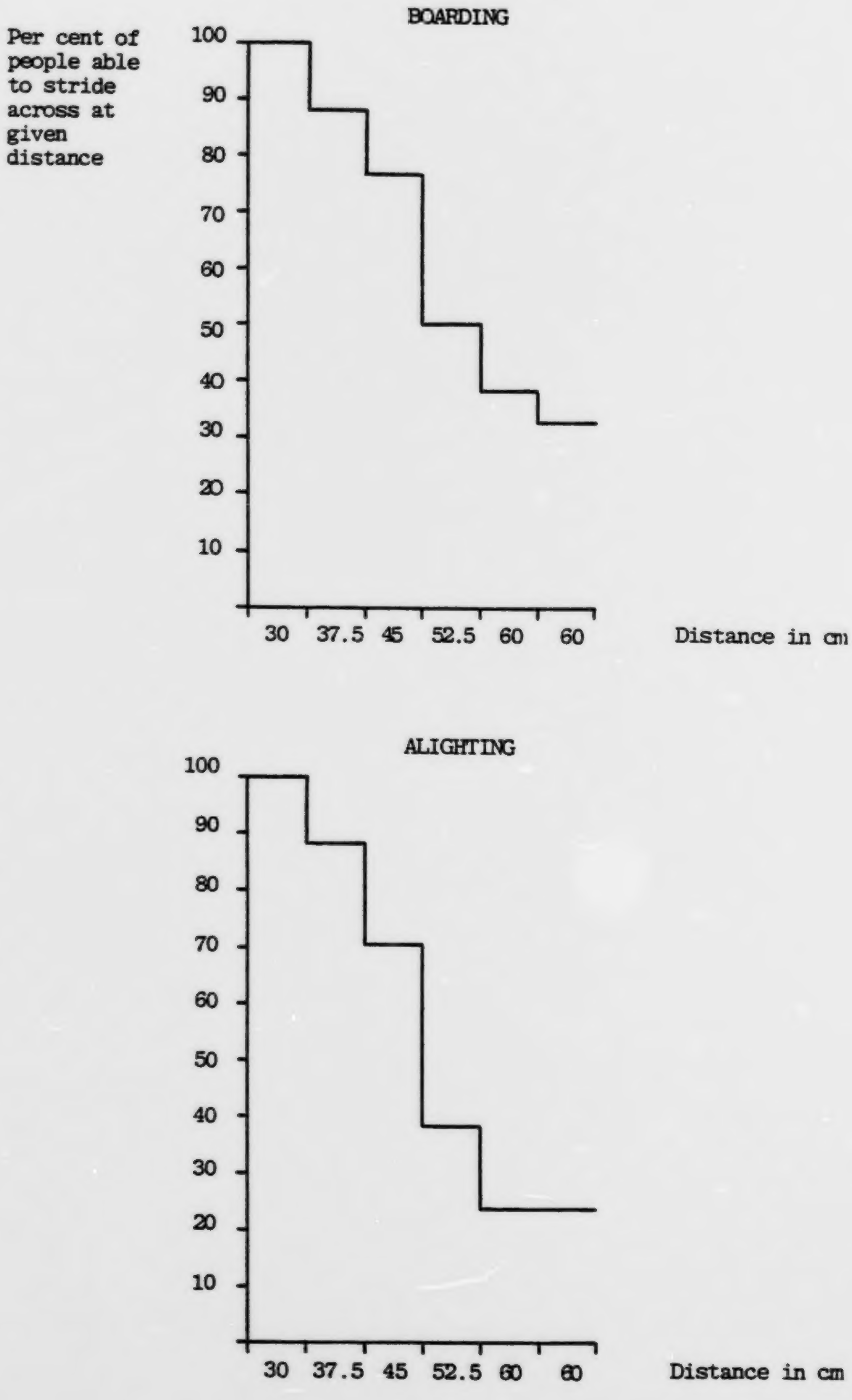


Figure 3

Stride Distances Between Kerb and Bus Step

ACCESS TO STANDARD PRODUCTION CARS BY DISABLED AND ELDERLY PEOPLE

Abstract

Magdalen Page, Julie Spicer, Ian McClelland, Kit Mitchell, Bob Feeney
John James.

The Institute for Consumer Ergonomics in Loughborough was commissioned by the Department of Transport through the Transport and Road Research Laboratory to investigate the problems experienced by disabled and elderly people when getting in and out of standard production cars.
The aims were:-

1) To provide information to help disabled and elderly people select a car which will allow them convenient access.

2) To provide car manufacturers and distributors with data on the problems which disabled and elderly people experience, with regard to car access, and to suggest possible ways of overcoming them, both in terms of car dimensions and customer service facilities offered.

The research programme comprised 2 main approaches each with two phases.
These were:- Surveys - Local Interview Survey
National Postal Survey
Laboratory Trials - Ergonomics Evaluation of 6 Production Cars
Investigation of Critical Aperture Dimensions

The characteristics and problems of the disabled and elderly car user are described. The results of the surveys indicated that disabled people frequently bought new cars. Their annual mileage did not differ significantly from that of the able-bodied population and when buying a car the disabled car user was interested in general car performance as well as features which affected their ease of entry and exit. They experienced difficulty getting in and out of cars and in stowing and retrieving their mobility aids.

The laboratory trials showed that specific car features frequently caused difficulties, for example, door pockets, the amount of fore and aft seat travel and seat height. Values for critical dimensions such as door length, door height and sill height were also established which minimised difficulties and which fell within the ranges found in cars currently available in the UK.

The research shows the nature of the problems experienced by elderly and disabled people and shows how they might be overcome. It also indicates that most disabled and elderly people could be accommodated within the scope of 'standard' vehicles although a small proportion would still require specialised vehicles.

It is to be hoped that car manufacturers will consider incorporating the results in a prototype vehicle which, after careful ergonomics evaluation could become a future production car.

ACCESS TO STANDARD PRODUCTION CARS BY DISABLED AND ELDERLY PEOPLE.

Magdalen Page
Julie Spicer
Ian McClelland
Kit Mitchell
Bob Feeney
John James

Introduction

In 1982 the Transport and Road Research Laboratory, on behalf of the Department of Transport, commissioned the Institute for Consumer Ergonomics in Loughborough to investigate the problems experienced by disabled and elderly people when getting in and out of ordinary production cars.

The primary aims were:

1. To provide disabled and elderly people (both drivers and passengers) with the information necessary for choosing a car which would allow them convenient access.
2. To provide car manufacturers with data on the problems experienced by disabled people with regard to car access, with a view to overcoming them in future design.

The 16 month research programme consisted of four consecutive phases comprising two surveys to obtain qualitative background information and two laboratory studies to obtain detailed quantitative information. The phases were as follows:

1. A local interview survey (57 subjects)
2. A national postal survey (588 subjects)
3. Trials with 6 production cars (64 subjects)
4. Trials with an adjustable car 'buck' (60 subjects).

2.0 Survey Methodology

2.1 Local Interview Study

This small scale interview survey of 57 disabled and elderly car users was carried out in the county of Leicestershire. The aims of this survey were to gain basic information about the types of cars used by the sample, their reasons for choosing their particular cars, and the problems they experienced with regard to access. Each subject was asked to answer a series of questions and to demonstrate their methods of getting into and out of their own car so that the interviewer could record details.

Details of the Sample

Of the 57 people interviewed, 28 were drivers and 29 were passengers. Twenty seven were men and 30 women. Wide ranges of age and disabilities were included and most people (84%) used a mobility aid.

Utilisation of the Results

This initial survey provided guidance for the subsequent stages of the research in particular the experimental protocol for user trials. On the basis of these detailed interviews, a written questionnaire was drawn up for the next phase, i.e. a Postal Survey. The results and conclusions of both surveys will be discussed together.

2.2 National Postal Survey

In order to obtain a broader view of the problem, a national postal survey was carried. Whilst it is accepted that the sample could not be considered truly representative of the national population of disabled car users, it did give a much needed insight into some of their typical problems. Invitations to take part were inserted in suitable publications and 920 people expressed interest and were sent a 12 page questionnaire consisting of 5 sections:-

1. General Information
2. Your disability
3. Your car
4. Using the car
5. Choosing another car.

Details of the Sample

Of the 588, 453 (77%) were drivers (294 of whom were also sometimes passengers) and 135 (23%) were passengers. 324 (55%) were men and 264 (45%) women. A very high proportion used a mobility aid and a third used more than one, the commonest combination being a wheelchair and one or two sticks. Almost three quarters used a wheelchair.

Most respondents were regular car users, for example 88% of the national sample used their car several times a week and almost half, 48% used it more than once a day. The average annual mileage of the drivers is estimated to be rather more than 8,000 miles: this may be compared with the UK national average statistics for 'all cars, vans and taxis' of 9,400 miles. The vast majority of the respondents necessarily took their mobility aid with them in the car.

Access to the Cars

The postal samples were classified according to their reported functional disabilities as follows:

Table 1: Classification of Postal Survey Sample by Functional Disability

	Number	Per cent
1. Limitation of upper limb only	12	2.1
2. Limitation of lower limb only	181	30.8
3. Limitation of both upper and lower limbs	196	33.3
4. Total loss of use of both lower limbs but unrestricted upper limb function.	102	17.3
5. Total loss of use of both lower limbs and restricted upper limb function.	77	13.1
6. No reported upper or lower limb restriction (includes those with back problems and those of very small stature)	20	3.4
TOTAL	588	100.0

Their techniques of entry and exit were then analysed and it was found that 4% needed to be lifted bodily in and out of their cars. A further 33% also needed the help of an assistant, sometimes only to stow a wheelchair, whilst 49% could manage entry and exit with just their mobility aid to help. Fourteen per cent required neither an assistant nor an aid.

The normal car entry technique used by the able-bodied involves twisting, ducking and transference of weight while balancing on one leg, grasping various parts of the car for support in the process. It was found in the interview survey that the majority of disabled and elderly people used other methods according to their various impairments and this was confirmed by the postal survey.

The most common method of entry for those who could stand but could not readily manage the technique used by the able-bodied was to sit sideways with both legs out of the car and then swivel round to bring the legs in, either both together or in succession: any sticks or crutches were brought in after the person was seated. Any instability due to one-legged support was thus obviated. Similarly on leaving , such people typically put out any stick or crutch first, then swivelled round and put their legs out to ensure stability before rising from the seat. Various parts of the car were used for support while rising, e.g dashboard, facia, door, seat back.

People who had to make a sideways transfer from a wheelchair usually either swung into the car using their arms or slid sideways with or without the help of an assistant.

In addition to a person's handicap, certain car features affected the ease of entry and exit. The main features were the seat height and cant rail (lintel) height. Other secondary features were the angle to which the door opened, the presence or absence of suitable handholds and interior obstacles such as door pockets.

Stowage of Aids

Small aids such as sticks and crutches were rarely a problem but large bulky items such as wheelchairs or walking frames were frequently difficult, and 43% of the postal survey respondents needed help to stow their aid.

Description of the Cars

A wide variety of cars were found in both surveys. Approximately half of the cars were 4 door models and almost three quarters of the drivers had cars with automatic transmission.

In the postal survey, the 6 most commonly occurring types of cars accounting for 18.5% of the total were:

Ford Escort, Disabled Drivers Model	38	(5.03%)
Austin Mini 1000 HL	32	(4.24%)
Austin Metro 1.3	28	(3.71%)
Austin Mini Clubman	19	(2.52%)
Renault 5 Automatic	12	(1.59%)
Volvo 343	11	(1.46%)

Over half of the cars had been bought new within the previous 4 years and the major features considered by the owners when purchasing were stated to be:

Automatic transmission	42.1%
Wide/large door: Easy Access	40.8%
Economical to run	27.2%
Purchase price	25.6%
Comfortable/high seats	23.4%
Reliable/easy to maintain	23.2%

In other words they were interested in general car performance features as well as those relating to easy access.

Most people both sat in the car and tried to find out if the car would be suitable for them prior to purchase. However under a third of drivers actually drove the car as they needed hand controls which were not fitted until after purchase, when just over half of the drivers had hand controls fitted to their cars, chiefly brake/accelerator modifications. Other modifications included pedal modifications, steering wheel knobs, extended seat runners and alterations to the seat or cushions.

Utilisation of the Results

The postal survey confirmed that the local sample of disabled and elderly car users was sufficiently broadly based for it to be used in the laboratory trials. On the basis of the data obtained from the surveys, the methodology of the laboratory trials was established.

3.0 Trial Methodoldogy

3.1 The Car Trials

Following the identification and classification of the problems experienced by disabled and elderly people when getting in and out of cars, the aims of the car trials were:

1. To identify and measure the principal dimensions of cars, associated with door apertures and seats, which have a critical influence on the ease of entry and exit.
2. To estimate, from analysis of the measurement of these cars dimensions giving minimal problems, and establish a suitable range for each dimension to be incorporated in the subsequent experiments with an adjustable 'buck'.
3. To provide, in conjunction with the car 'buck' trials, guidance for car manufacturers and car users regarding acceptable dimensions for the most critical features.
4. To provide manufacturers with information on the effect of detailed design features of the cars used in the trials.

To achieve these aims, 6 cars which reflected both the aperture sizes and current design practice were obtained and a group of disabled and elderly people were studied getting in and out.

The 6 cars, all 1983 mdels, were:

Ford Escord Disabled drivers model	2-door
Volvo 343 Automatic	2-door
Austin Metro	2-door
Honda Accord Automatic	2-dor
Vauxhall Cavalier	4-door
Renault 5	2-door

They were selected to give a wide varation of dimensions within the normal range of currently available popular cars. The intention was not to directly compare the cars themselves but to identify how features influenced ease of entry and exit. The subjects entered each car in a systematic fashion and detailed observations and written records were made of the sequence of moves, and the hand holds used and any problems encountered.

In addition, the subjects were asked to discuss the procedure, note any difficulties and rate the degree of difficulty of each part of the trial. For each car, the dimensions which might affect ease of entry and exit were measured to enable the dimensions of the car 'buck' to be better estimated.

Details of the Sample

A total of 64 subjects took part; 34 men and 30 women. Thirty one were drivers and 33 were passengers.

There was a lower incidence of mobility aids, particularly wheelchairs, than amongst the two surveys, due to the need for people fit enough for the fairly strenuous trials. To produce comparative data for able-bodied people, a few fit young people also completed the trials.

Utilisation of the Results

The data gathered in the car trials were of fundamental importance to the ultimate aim of providing advice for disabled and elderly car purchasers, and for car manufacturers wishing to meet these needs.

However, the immediate practical application of the data was to design the car 'buck'. Thus a number of critical dimensions were identified as follows:

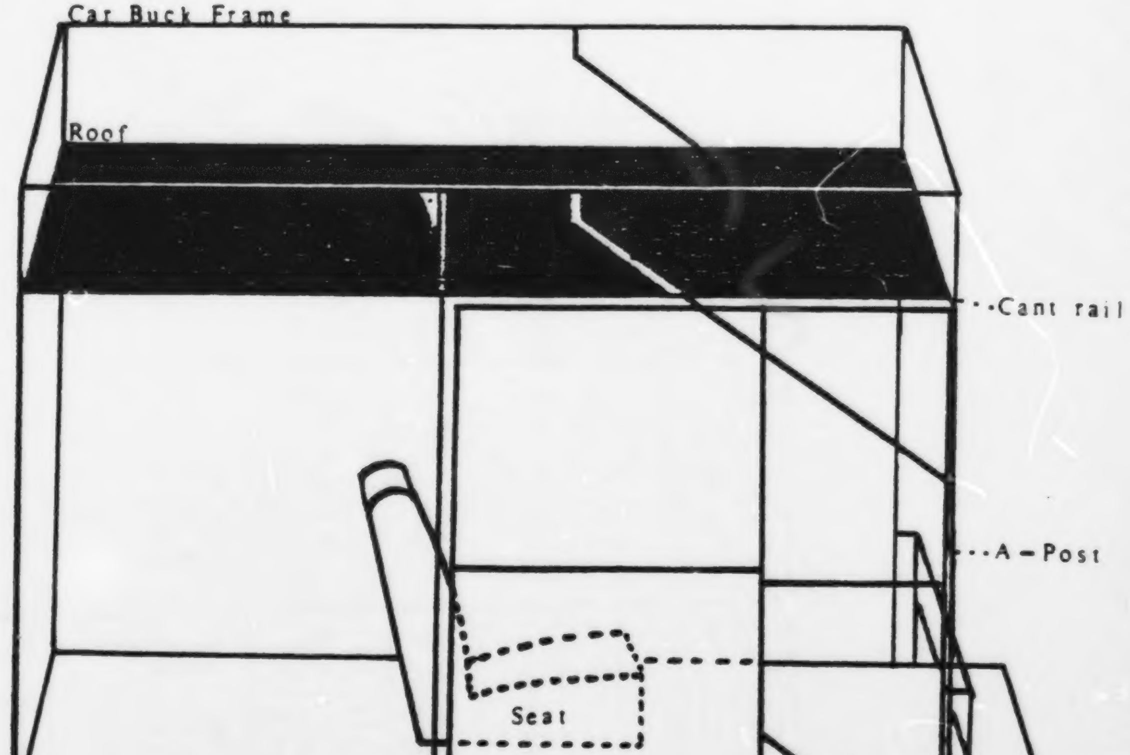
- The height of the cant rail (lintel) from the sill
- The height of the sill from the ground and the depth of the footwell
- The height of the seat from the sill and the ground
- The longitudinal clearance between the seat and the front door pillar or 'A' post.
- The 'A' to 'B' post distance
-

A comparison between the level of problems encountered with the associated aperture dimensions for the cars, enabled regression equations to be developed. These equations in turn enabled estimates to be made of the values for aperture dimensions which caused none of the subjects problems and conversely the dimension which caused 100% of the subjects problems. These dimensions were then used as a basis for selecting the range of adjustments in the 'buck' trials. The effects of each of these critical dimensions on the ease of entry and exit will be discussed together with the complementary 'buck' results.

3.2 The 'Buck' Trials

Having established the car features which caused problems in the car trials and estimated a theoretical 'ideal' set of dimensions which should cause minimal problems, it was necessary to test them. This was done with an adjustable car 'buck' which allowed the systematic alteration of one dimension at a time using a similar group of people to those in the car trials. The buck shown in Figure 1 comprised a tubular frame with solid floor and roof, hinged doors, a dashboard, pedals and a steering whelel. Genuine car seats, which moved back and forth, up and down and sideways were provided for the driver and passenger. The horizontal datum plane was the ground and the vertical datum plane was the front door pillar or 'A' post.

Figure 1. Diagram of the car 'buck'.



The range of adjustment for each dimension was arrived at from studying current car dimensions, the predictions from the car trials and pilot trials. The final choice is shown in Table 2

TABLE 2 Summary of Data Used to Select the Range of Adjustment Examined in the Car Buck Trials

FEATURE	'81 CAR DIMENSIONS	USER TRIAL CAR DIMENSIONS	BUCK RANGE	ESTIMATED 'IDEAL' FROM CAR TRIALS	SELECTED RANGE
Door Angle	-	-	0 - 180°	-	45-90°
Lateral Position of Seat	100-210	150-180	85-275	-	100-210
(Back of) Seat Height to Ground	(Front of) 490-650	440-490	470+	(Front of) 613	470-585
Sill Height to Ground	330-450	340-440	180-390	271	240-390
Footwell Depth	60-200	100-195	0-195	59	50-100
Seat Front Edge To 'A' Post (Rearmost Position)	(Back Seat to 'A' Post) 720-890	340-440	240-500	477	340-500
Cant Rail Height to Ground	1219-1333	1235-1320	1240-1720	-	1260-1560
'A' to 'B' Post	740-1150	810-1065	770-1650	1208	770-1150

Units of measurement in millimetres unless otherwise specified

To minimise the effort involved in testing each dimension a rationale was developed to examine each feature in turn and thus establish a set of dimensions which each subject regarded as the limit of their acceptability. Having established these, a composite arrangement could be set up and the subject asked to check that this was, after all, acceptable overall.
The order of testing was:

- door angle
- lateral seat position
- minimum seat height
- maximum sill height
- maximum foot well depth
- minimum seat front edge to 'A' post
- minimum cant rail height
- minimum 'A' to 'B' post.

Details of the Sample

Sixty people, took part. There were 38 men and 22 women, 35 drivers and 25 passengers.

Identification of Critical Features and Dimensions

Door Opening

Some doors on the trial cars were found to be heavy to pull (Volvo 343) and many were hard to reach without leaning very far out of the car. The buck trials found that an angle of 75° was generally acceptable to all except those with special needs such as long unbending legs who might need 90°.

Lateral Distance of the Seat from the Outer Sill Edge

Most subjects found 140mm acceptable, anything greater than this caused difficulty. Three of the six trial cars were within this limit.

Seat Height above Ground Level

In the car trials, the seat heights at the front ranged from 490mm to 650mm, and analysis predicted few problems at a height of about 613mm. This is approximatley equivalent to a height of 510mm at the back of the seat. This was confirmed by the 'buck' trials where 88% accepted 510mm. However, some people have special needs which can only really be met by an adjustable height seat.

Sill Height above Ground Level

Everyone in the buck trials found a sill height of 240mm acceptable, but above this height acceptability declined until only 20% found 390mm acceptable. None of the six cars in the trials had a sill below 340mm and three of them had sill heights of 390mm or greater.

Footwell Depth (Sill height above car floor)

Deep footwells such as was found in the Austin Metro (195mm) cause great problems when leaving the car. The ideal situation is to have a flat floor with no footwell but if it is necessary to have a footwell, it should not exceed 50mm.

Front of Seat to 'A' Post

The longitudinal leg clearance between the seat fron edge and the bottom corner of the 'A' post is critical during entry and exit. Any obstacles such as door pockets situated in this region greatly exacerbate the problem.

Table 3 below summarises the dimensions acceptable to most elderly and disabled people together with the corresponding dimensions on the six cars used in the user trials.

Table 3: Dimensional Limits for 90% or greater Acceptance, as a Result of the Buck Experiments, compared with the Dimensions of the six Cars used in the earlier Trials.

FEATURE	Dimensional limit for 90% or greater acceptance	Measured Dimensions (mm)					
		Ford Escort	Volvo 343	Austin Metro	Honda Accrd	Vauxhall Cavalier	Renault 5
Door angle	75° optimum	-	-	-	-	-	-
Seat to outer sill edge	140mm max.	130	140	135	150	180	160
Seat height above ground	510mm opt.	450	545	460	440	450	540
Sill height above ground	240mm max.	340	410	390	350	365	440
Footwell depth	50mm max.	110	140	195	100	120	130
A-post to seat front edge	450mm min.	450*	440	345	390	358	340
Cant rail height above g'd	370mm min.	1270	1320	1270	1235	1240	1290
A-post to B-post	980mm min.	1030	1065	990	1050	800	935

* Specially available on the Disabled Driver's model only.

Supports Used during Entry to the Trial Cars

A variety of parts of the trial cars were used for support during entry and exit. In many cases the car parts used for support are likely to suffer abnormal wear and tear as a result of such usage. This is particularly true for the door where approximately half of the subjects leaned on the front of the top edge of the door thus putting a great strain on the door hinges.

Results from the Able-Bodied Subjects

Whilst the number of able-bodied subjects was very small, it is interesting to note that during the car trials, they were found to be troubled by the same features as the disabled and elderly people, although they could obviously cope more readily.

Utilisation of the Results

The results of the whole programme are to be used to produce a report aimed at car manufacturers, advising them of the needs of disabled and elderly people. Already car manufacturers are showing interest in the results with a view to incorporating them in future car designs.

A further booklet aimed at disabled and elderly people themselves is also to be produced to help them select a car suited to their needs and disabilities.

4.0 CONCLUSIONS

The research programme has shown that the disabled, elderly and the able bodied all experience similar problems with cars. Many of these problems are due to detailed design considerations rather than to structural engineering aspects. Thus the clear design guidelines which have emerged are compatible with current car styling and will benefit all car users.

None of the recommended dimensions are beyond the range currently available on popular cars, although at present no single car incorporates them all but it is hoped that this will be remedied in the future. Meanwhile, much of the data on detailed design features can help the disabled traveller by suggesting the important access features to consider when buying a car.

Making Crossing Structures Accessible for Elderly and Handicapped Pedestrians

by

Richard A. Richter and John C. Fegan

Introduction

Pedestrian overpass and underpass roadway crossing structures installed principally as safety improvements have been ignored by some pedestrians who seem to prefer the shorter, more dangerous, but slightly more convenient at-grade path across a roadway. A small group of the pedestrian population, the elderly and handicapped, however, typically prefer the safer but longer route across a structure. Nevertheless, the crossing structure still may not be a completely satisfactory crossing solution for elderly and handicapped pedestrians if their physical limitations are not compatible with some of the structure's design features. Structure designers have for some time weighed the alternatives for making overpass and underpass crossing structures more serviceable to pedestrians. Of principal interest have been the approaches to the structure. Some handicapped pedestrians, such as those in wheelchairs, need a ramped surface to climb approximately 20 ft (6.1 m) to the walkway of most overpass structures. Other handicapped pedestrians, such as those on crutches, are better able to climb on stairs. Persons with restricted vision can be aided by guidance strips and tactile warning surfaces. Still other handicapped persons avoid relying on such special devices, stating that without uniform application, dependence on these devices is dangerous. Highway officials recognize the need to make pedestrian crossings as accessible as possible to all potential users and must deal with the problems of balancing cost with anticipated use, the conflicting demands of different handicapped users, and the trade offs between accessibility and user convenience.

Determining User Needs

A suitable pedestrian crossing structure should be accessible to a degree equal to or greater than the present or proposed accessibility of connecting routes. This can be readily determined if the Priority Accessible Network (1)[1] concept has been adopted. The Priority Accessible Network concept involves designating principal access routes for elderly and handicapped pedestrians, prioritizing the upgrading of those routes, and developing full accessibility for all major categories of handicapped pedestrians on each route at one time. As a major component of pedestrian routes, existing crossing structures often would be targeted for conversion to add accesible features or possibly added to the route system as a completely new link to an existing inaccessible network. One approach to determining the degree to which accessibility features should be added is to consider that elderly and handicapped pedestrians exist in a representative percentage within the overall pedestrian population. As the estimated pedestrian volume using a structure increases, so does the usage by the elderly and handicapped pedestrians. Many of the features such as rest areas, benches, lights, and special signs would then take on added importance as the overall pedestrian volume increases.

One of the most difficult aspects of designing a suitable pedestrian crossing structure is determining in advance the volume of use and nature of the users for the proposed crossing. Origin and destination surveys can estimate pedestrian desires to cross a physical barrier, but this potential will not be realized unless a sufficiently easy-to-use and convenient crossing facility capable of generating pedestrian use is provided. In trying to estimate use by the elderly and handicapped, the problem becomes even more difficult. Even if physical barriers are removed at a crossing, specific categories of handicapped persons may not use that particular crossing.

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[1] Italic number in parentheses identifies reference

Two design philosophies are suggested. One is to survey the area surrounding a proposed pedestrian crossing to estimate the population of elderly and handicapped pedestrians. Then categorize those potential users into specific groups having similar needs for specific design features. The designer then is able to develop the required crossing facility features. Conflicting requirements of some categories of elderly and handicapped can be resolved when the categories are found within the survey area.

The other design philosophy is to assume that the structure will be used by all of the major categories of elderly and handicapped pedestrians and to design the structure, approaches, and end connections with all of the desired features. This approach saves the time and expense of conducting a user survey but may unnecessarily add to the expense of the structure by including features that are not needed and rarely would be used.

A manual has been developed to aid structural designers in choosing what design features to provide and those to avoid, as well as appropriate specifications to insure usable features for the handicapped pedestrian. (2)

Two Principal User Categories

Two major groups of elderly and handicapped pedestrians are of principal concern in relation to crossing structures--those in wheelchairs and those who are blind. Wheelchair users need a ramp or mechanical lift to gain the elevation required to cross on a structure. Ramps appear to offer the best solution, but the optimum combination of grades and ramp length is sometimes hard to determine. Users range in their physical capability to travel on steep ramps. As ramp grades are made progressively less steep, they become longer--another undesirable characteristic. The basis for selecting ramp grades and the tolerance of users to long ramps have been investigated and are described later in this article.

The other user category, the blind, are not a homogeneous group when needs are considered. In addition to ranging from the completely blind to the "legally blind" with limited sight, there are varying degrees of philosophies and techniques used by the blind for pedestrian movement. Some blind pedestrians prefer to perfect movement techniques allowing them to move without auxiliary aids. Others can facilitate travel by using supplemental aids for guidance, even though these aids are not provided everywhere. Typically, handrails are provided and serve to direct blind pedestrians across structures. A more recent development being considered for the blind pedestrian is the tactile strip or textured surface located for guidance along travel paths and for warning across paths. Blind pedestrians identify these strips with a long cane.

Until recently, not much was known about the kinds of surfaces that can be detected and identified using a cane or the criteria for determining a slipproof surface on ramps and stairs. A method for specifying such surfaces when designing pedestrian overpass and underpass crossing structures was needed as well as a better understanding of the abilities of elderly and handicapped pedestrians to travel on sloping ramped walkways.

Research on Accessibility Features

Ramp grades

Research was conducted to determine the length, gradient, and rest area configurations for long ramps. (3) Previous research had investigated gradients of ramps up to 40 ft (12.2 m) long. (4) Pedestrian overpasses could, however, require ramps of up to 240 ft (73 m) long. Six ramp gradients from 1:10 to 1:16 were tested using 102 disabled subjects. On long ramps, the most important predictors of an individual's performance were his or her physical capabilities, age, sex, and other factors such as motivation, physical strength, and stamina. Physical characteristics of the ramp are much less important, but among these characteristics, gradient is the best predictor of performance.

Analysis of the performance of manual wheelchair users indicates a relationship between users' abilities to climb ramps to a certain vertical height and the ramp gradient. The recommended gradients in table 1 accommodate 80 percent of manual wheelchair users.

Table 1.—Ramp gradients for various climbing heights

Ramp gradient	Maximum vertical height	Maximum linear distance exclusive of rest area
	Feet	Feet
1:10.1 to 1:11.0	9	91.3/99.4
1:11.1 to 1:13.0	14	156.0/182.5
1:13.1 to 1:15.0	16	210.2/240.5
1:15.1 to 1:16.0	20	320.7/320.5

1 ft=0.305 m

Landing locations

For long ramps, 85 to 95 percent of test subjects were able to travel a considerable distance to their first rest stop. Subsequent rest stops need to be closer together. The location of the first rest stop is between 4.5 and 6.0 vertical ft (1.4 and 1.8 vertical m) depending on ramp gradient. Thus, the first rest stop should be located at 45 ft (13.7 m) for a 1:10.0 ramp and at 95 ft (29 m) for a 1:15.9 ramp. Results of field tests indicate that ramp configuration (straight, dogleg) does not affect performance. (3) However, helical ramps are more difficult to negotiate and require a more gradual gradient for the user to perform as well as on a straight ramp.

Slip resistance of walkway surface materials

Twelve level walkway surfaces were tested for slip resistance (table 2). Coefficients of friction greater than 0.3 are adequate for level pathways, but 0.4 or 0.5 is preferred. Thus, all of the tested materials meet this criterion. To convert these coefficients of friction to those for sloped surfaces, the following equation is used:

$$y=\frac{x}{\cos a}+\tan a$$

Where,

y=Static coefficient of friction on an inclined surface.

x=Static coefficient of friction on a horizontal (level) surface.

a=Angle on incline.

Table 2.—Static coefficients of friction for various surface materials (level surfaces)

Surface material	Shoe material	
	Leather (dry)	Neolite (dry)[1]
Brushed concrete New, against the brush	0.75	0.90
Asphalt tile Waxed, heavy use area	0.56	0.47
Smooth metal Rusted slightly	0.54	0.49
Asphalt Old parking lot	0.53	0.64
Checker plate Rusted moderately	0.50	0.64
Quarry tile Unglazed 6 in x 6 in tile	0.49	0.60
Thermoplastic Used on crosswalk	0.45	0.86
Brick pavers On stair, new no finish	0.43	0.73
Exposed aggregate Pea gravel, heavy traffic	0.41	0.57
Granite Stairs, old, exterior	0.40	0.66
Plywood "A" side With grain, no finish	0.39	0.75
Plywood "A" side Against grain, no finish	0.38	0.51

[1] Neolite was sanded smooth and flat.

1 in=25.4 mm

The minimum coefficients of friction need to be greater for sloping ramps than for level surfaces. For a 1:10 ramp, for example, the minimum coefficient of friction required is 0.502 and the preferred value is 0.603. This corresponds to 0.40 and 0.50 for level walkways. Table 3 illustrates the minimum coefficients of friction acceptable for roofed areas and external surfaces. Fewer than one-half of the surfaces when tested with leather soles meet the acceptable minimum, and only brushed concrete reaches the preferred level.

Surface Detectability

Twenty-two visually impaired people with little or no functional vision traversed orientation and warning test panels, and their abilities to detect each panel using a cane were recorded. Three qualities of surface materials were considered--surface texture, rebound, and impact sound. The tests indicated that the sound made as the cane traveled the walkway surface was the major factor in detectability. Texture of the panel also was useful.

Orientation cues

Five tasks are particularly troublesome for visually impaired persons attempting to cross roadways: Crossing open space, traversing nonperpendicular path intersections, finding the appropriate place to cross a street, finding an end connection from a broken or uneven path, and finding a dirt or gravel path end connection from a paved path.

Table 3.--Static coefficients of friction for level and inclined surfaces

Level surface	Gradient[1]					
	1:20 (5%)	1:18 (5.55%)	1:16 (6.25%)	1:14 (7.14%)	1:12 (8.33%)	1:10(10%)
Minimum preferred for external surfaces:						
0.80	0.851	0.856	0.861	0.874	0.882	0.904
0.75	0.801	0.806	0.812	0.824	0.832	0.854
0.70	0.751	0.756	0.761	0.774	0.782	0.804
0.65	0.701	0.706	0.711	0.723	0.732	0.753
0.60	0.651	0.656	0.661	0.673	0.682	0.703
0.55	0.601	0.606	0.611	0.623	0.632	0.651
0.50	0.551	0.556	0.561	0.573	0.582	0.603
Minimum acceptable for external surfaces:						
0.45	0.500	0.505	0.511	0.521	0.531	0.552
0.40	0.450	0.455	0.461	0.472	0.481	0.502
Minimum acceptable for roofed areas:						
0.35	0.400	0.405	0.411	0.422	0.431	0.452
0.30	0.350	0.355	0.361	0.372	0.381	0.402

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[1] The figure for the inclined surfaces is a calculated value. This value indicates that as the gradient of the walkway increased, a material with a higher coefficient of friction becomes necessary.

Six countermeasures improved performance of the test subjects. These include the following in descending order of performance:

o A wooden shoreline--a 1 in x 6 in x 8 in (25 mm x 152 mm x 203 mm) board staked to the ground paralleling the route.

o A sound-emitting device that produces a loud "chirp-chirp" noise to indicate an appropriate crossing location and time.

o A metal plate.

o A wooden plate--a 4 ft x 8 ft x 0.5 in (1.2 m x 2.4 m x 12 mm) sheet of plywood.

o A rubber mat.

o A carpet mat.

As with testing on surface detectability, landmarks that produce loud noise when struck with a cane are helpful as orientation cues; distinctive rebound, as in the case of the rubber mats, is less helpful.

Needed Research

Relationships need to be developed between the volume of anticipated usage by representative categories of elderly and handicapped pedestrians and the design features intended to insure accessibility for the users within each category. Design features need to be identified as to their importance for accessibility, that is, whether they are absolutely essential for accessibility or are optional features that merely would facilitate movement of the elderly and handicapped pedestrians.

User manual

A manual has been developed to aid structural designers in chosing what design features to provide and those to avoid, as well as appropriate specifications to insure usable features for the handicapped pedestrian. (4)

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[2/] Report with PB number is available from the National Technical Information Service, 5285 Port Royal Rd., Springfield, Va. 22161.

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SURVEYING THE DISABLED - CONCEPTUAL AND OPERATIONAL PROBLEMS

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Abstract

In 1981 Statistics Canada began a process to establish a disability database which, when completed, will constitute an amalgamation of several data sources. One of the components of the disability database is a national household disability survey. This paper attempts to provide an overview of the conceptual and operational problems associated with the development of that national disability survey. It is hoped that the experience gleaned through Statistics Canada's work in this complex area of survey research will be helpful to those persons interested in pursuing the development of surveys to provide data on the needs of the disabled. The data available from this survey undertaking will provide the information necessary for the evaluation of programs and technologies intended to initiate new services or improve existing services for disabled persons.

This paper is presented in three parts. The first portion deals with the problems associated with selecting from a general survey individuals who are disabled, as well as a review of the methodology used by Statistics Canada to determine the appropriate selection criteria to identify the disabled in a general population survey. The second part presents some results of the testing conducted by Statistics Canada and a discussion of operational problems associated with the collection of data from disabled persons. The third and final part of the paper presents the final screening device established by Statistics Canada.

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[1] Prepared for the Third International Conference on Mobility and Transport for Elderly and Handicapped Persons, October 1984.

Selection of the Target Population

In survey research it is almost always true that the survey results one obtains are a function of the questions one asks. Nowhere is this adage truer than with the subject of disability. The importance of the wording of questions and their subsequent implications on the data set is probably best illustrated by the now well known story of the two priests, a Dominican and a Jesuit. The two priests were discussing whether it is a sin to smoke and pray at the same time. After much discussion, from which no conclusions were drawn, each of the priests agreed to consult their respective superiors. The next week they met again. The Dominican asked, "Well, what did your superior say?". The Jesuit replied, "He said that it was alright." the Dominican was astounded and claims that his superior had informed him that it was a sin. The Jesuit inquires, "What did you ask him?" The Dominican repiled, "I asked him if it was alright to smoke while praying." "Oh," replied the Jesuit, "I asked my superior if it was alright to pray while smoking."

The illustration serves to underscore some of the concerns Statistics Canada had with the development of the appropriate line of questioning for their disability survey. The development of the initial questions which were intended to determine "who" was disabled hinged heavily upon the working definition of disability. As with the example of the two priests, the wording and administration of the questions intended to determine "who" is disabled were of paramount importance to the successful implementation of the survey. The definition of the population for which Statistics Canada was interested in collecting data is described as follows:

> All persons having one or more physical (non-behavioural) disabilities or knowledge acquisition or other educational disabilities (arising from inpairments in intelligence, attention, psychomotor functions and language), whose duration has been or is expected to last at least six months. Also included are persons suffering from diseases of a chronic degenerative nature, and which have a high probability of producing impairments which are physically disabling.

The rationale for the definition employed by Statistics Canada was influenced to a high degree by the World Health Organization (W.H.O.) definition of disability. The definition used for the survey is a spinoff of the W.H.O. model used to focus on the consequence of disease. On a continum the model looks somewhat as follows:

$$\begin{tikzcd}\text{DISEASE} \arrow[r] & \text{IMPAIRMENT} \arrow[r] \arrow[rr, bend right] & \text{DISABILITY} \arrow[r] & \text{HANDICAP}\end{tikzcd}$$

A working example of this continuum might be described as follows. If one was interviewing a person with serious heart disease one might expect the following implications within the framework described above:

DISEASE → BLOCKAGE OF THE VALVES IN THE HEART

IMPAIRMENT → POOR CIRCULATION, RESTRICTION OF THE BREATHING, PAIN IN THE CHEST

DISABILITY → INABILITY TO PERFORM NORMAL DAILY ACTIVITIES

HANDICAP → LIMITATION IN THE KIND AND AMOUNT OF WORK OR RECREATION

The task that faced Statistics Canada was to incorporate these definitions and concepts into a workable questionnaire which respondents would be capable of understanding and, at the same time, one which would yield the populations that fell into the scope of the definition of disabled. In order to assess the appropriate question sets, Statistics Canada conducted three different tests to determine the question options which might best identify the target population.

The main focus of the approach that Statistics Canada used to filter the population of interest, hereafter referred to as the "target population", was to develop a questionnaire which would act as a "screening mechanism". The screening mechanism was intended to identify those persons for whom a detailed follow up disability questionnaire was to be administered. The survey was thus a two stage operation. The first stage was to identify those individuals who fell into the target population. The second stage involved an in depth interview concerning various social and economic issues with those persons in the target population. The purpose of the tests was to determine which of the several screening mechanisms developed was best suited to meet the field collection operations, and at the same time remain congruous with the definitions described previously.

The principal area of interest, and the primary approach finally used to screen the general population to the target population, was a derivation of one that has been used in other surveys. The focus of the tests was to assess a set of questions on Activities of Daily Living (A.D.L.) which were combined with several other question sets that were considered as possible screening questions. The questionnaires used in the tests are presented in Appendix A.

The Activities of Daily Living are a set of activities that any person is required to perform during the normal course of their regular living pattern. There is no generally recognized "best" set of activities that should be used. However, in 1978, the Organization for Economic Cooperation and Development (O.E.C.D.) defined, through a working group composed of membership of several countries, a set of A.D.L.'s that could be used in most of the world's industrialized countries. It was a modified version of the A.D.L.'s developed by the O.E.C.D. that Statistics Canada was most interested in testing,since at the outset these A.D.L.'s appeared to be most likely to yield a population which fell within the parameters of the working definition of disabled.

The general population survey vehicle on which the disability survey screen tests, and subsequently the detailed follow up interviews were conducted, was the Canadian Labour Force Survey (L.F.S.). Appendix B of this paper briefly describes the sample design of the L.F.S. Persons who wish a more detailed description of the Canadian Labour Force Survey are referred to the Statistics Canada publication, The Methodology of the Canadian Labour Force Survey, Catalogue 71-526. For the purpose of the discussion here, we leave the description of the L.F.S. as a stratified multi-stage probability sample of approximately 56,000 households across Canada. The data produced from the L.F.S. are roughly analagous to the United States Bureau of the Census' Current Population Survey. It should be mentioned that the L.F.S. excludes persons living on Indian reserves, as well as persons who are institutionalized.

The Test Screening Questionnaires

The following section of the paper presents a description of the tests conducted to establish an appropriate screening mechanism. Test One looked at the possibility of defining the target population through the use of a single question approach. The idea behind the test of the single question was to assess how a self perception approach to the screen would work. At the onset it was expected that the defined population of interest might not be easily identified by a single question. The advantage of the single question approach was that it was the shortest and consequently had the lowest threshold of respondent burden. It suffered, however, from an inability to translate the definition of what constituted disabled to the respondents in the survey. The question that was used for test one was:

> DOES...NOW HAVE ANY DISABILITY OR HANDICAP WHICH HAS LASTED OR IS EXPECTED TO LAST SIX MONTHS OR MORE?

The second test attempted to assess three types of screening questions. The question types can be divided into three broad categories. These included:

1) The use of special aids (eg. wheel chairs, crutches, white canes etc.)

2) Activities of Daily Living with the use of special aids

3) Any other conditions or health problems which prevent or limit the respondent from carrying out his/her normal daily activities

Test Three was also composed of three sets of questions. These sets of questions are broadly categorized as follows.

1) Activities of Daily Living without the use of any special aids or devices

2) Limitation in the kind or amount of work

3) Chronic Conditions or health problems

The Results

The results of the three tests were very much dependant on the questions posed as well the respondents perception of the question. Table One summarizes the results of the screen rates yielded by the various tests. It is interesting to note that screen rates vary substantially between Test One (the single question) and Tests Two and Three (the more complex question sets). Test One screened in about 5.6% of the population while Test Two and Test Three yielded a screened in population of at least 15%, almost three times as many respondents as Test One. One of the hypotheses proposed for the very low screen rates for Test One was that the self perception question required the respondent to acknowledge a functional limitation in the form of a handicap or disability. In the other two tests the respondent is not required to acknowledge a disability or handicap. The manner in which the samples for the tests were set up permitted linkages between responses to Test One and those for Test Two and Three. Analysis of the matched data from Test One with the data from Tests Two and Three inidcated that the single question tends to only screen those persons who are more severely disabled. Using the one question approach as a screening mechanism is not recommended and was in fact dismissed as a viable screening tool by Statistics Canada. One further factor is worthy of note from Table one. It would seem that the differences in the screening rates between males and females are not significant regardless of the question sets used as a screen.

Table 1: Percent Screened in by each Section of each Test by Sex

	Percent Screened In	
	Male	Female
Test 1:	5.5	5.7
Test 2: ADL with aids	14.7	16.2
Test 2: Aids	3.2	2.9
Test 2: Other	5.9	6.1
Test 3: ADL without aids	15.4	16.7
Test 3: Work Disability	13.0	13.1
Test 3: Chronic Conditions.....	23.2	24.6

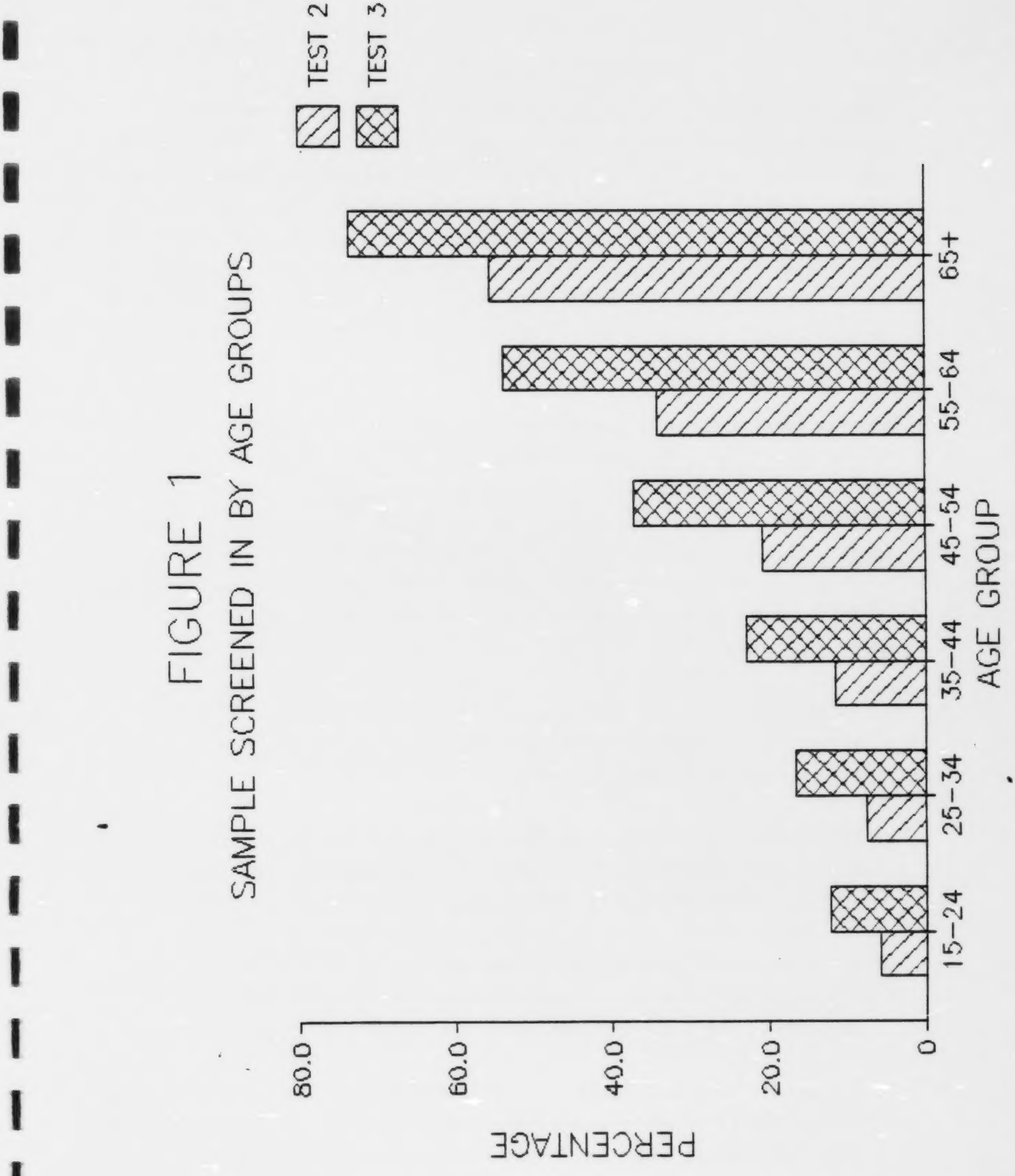
The comparative analysis of the data from Test Two and Three centered on the issue of special aids and their subsequent effect on the screen rates for the Activities of Daily Living. The concern was that the introduction of the use of special aids such as wheel chairs, crutches, walking devices, etc. would negate the utility of the A.D.L.'s as a screening device. The analysis of the data from Test Two (A.D.L.'s with the use of special aids) and Test Three (A.D.L.'s without the use of special aids) shows no significant differances between the screen rates. The hypothesis presented as a result of the analysis was that although the use of a special aid may help a person with a functional limitation it does not completely eliminate all of the trouble the person may have performing the daily activities. Consequently, special aids have no significant impact on the screen rates one might expect from the list of A.D.L.'s constructed for the Statistics Canada disability survey.

One factor which does, however, have a significant effect on the screen rates is the age of the respondent. For both Test Two and Test Three the likelihood of being screened into the disabled population increases with age. Not suprisingly, the likelihood increases more rapidly the older the population of interest becomes. Figure One graphically represents the screen rates for various age groups for both Test Two and Test Three. Consequently, some questions were raised as to the applicability of the A.D.L.'s to more elderly populations and some consideration has been given to the development of a special set of A.D.L.'s for populations over the age of 65. The reason for the special consideration for elderly populations is that although the screening rates are higher for persons over 65, the degree of disability may not be as acute for these elderly persons as for younger respondents who are screened in by the same criteria. In fact a cursory analysis of the reasons for persons 65 years of age and older being screened in by the A.D.L.'s in many instances showed the reason as being "old age".

The list of chronic conditions used on test three yielded some interesting results in the context of a screening mechanism. It appears from the analysis of the chronic conditions data that many persons who claimed to have some chronic condition experienced no functional limitations as described by the A.D.L.'s. Further many of these people experienced no work or other activity limitations. Analysis of the data from Test Three

FIGURE 1

SAMPLE SCREENED IN BY AGE GROUPS



shows that at least ten percent of the persons screened in by chronic condition or health problem had no trouble with the A.D.L.'s. For example, many persons identified high blood pressure as a condition which had no effect on their daily activities. A further problem which arose with the use of chronic conditions was the inability (or reluctance) of some respondents to classify their chronic condition on the list provided. As a result of the two problems described above, Statistics Canada decided to eliminate the use of chronic conditions as a viable screening mechanism to delineate the population of interest.

Figures Two and Three illustrate the percentage of the population screened by the various question sets for Test Two and Three. As is illustrated, the A.D.L.'s by themselves and in combination with other question sets yielded the largest proportions of the population for both Test Two and Three. It is also worth noting that in each of the tests the A.D.L.'s were roughly consistent in the percentages of the population that they screened. The major conclusions that were a result of the test process described above were that:

1) The definition of the population of interest is important to the successful implementation of any survey but is critical when dealing with collecting disability data.

2) The inclusion or exclusion of special aids does not effect the A.D.L.'s as a screening mechanism. Screened in rates appear to remain consistent with or without the use of special aids.

3) While the sex of the respondent does not seem to be a factor in the screen process, age is a factor in the use of A.D.L.'s as a screen mechanism. The older the population the higher the screen in rate.

4) The use of the A.D.L.'s, while appropriate for the population of interest for Statistics Canada's disability survey, may yield higher screened in rates for studies with more restricted population definitions.

FIGURE 2

PERCENTAGE OF POPULATION SCREENED

TEST 2

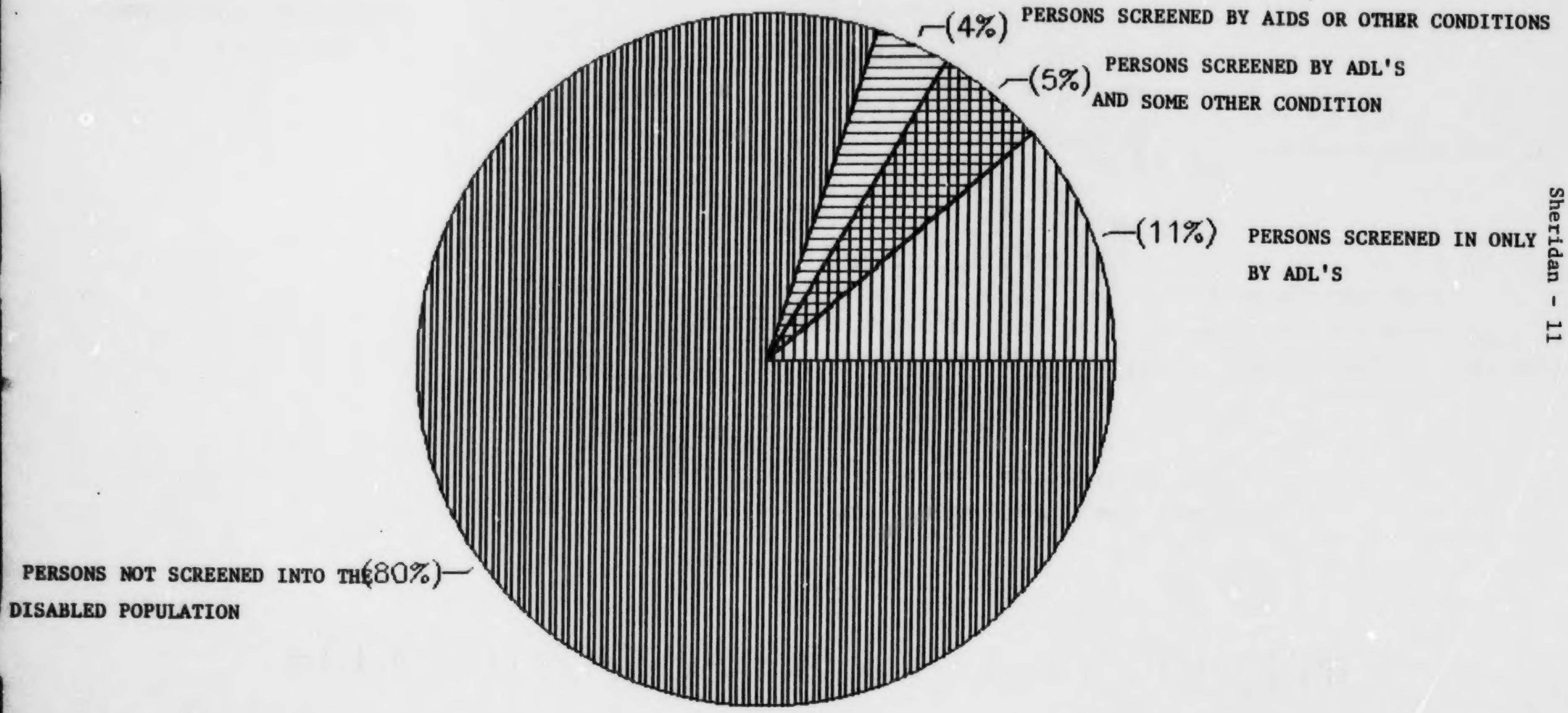
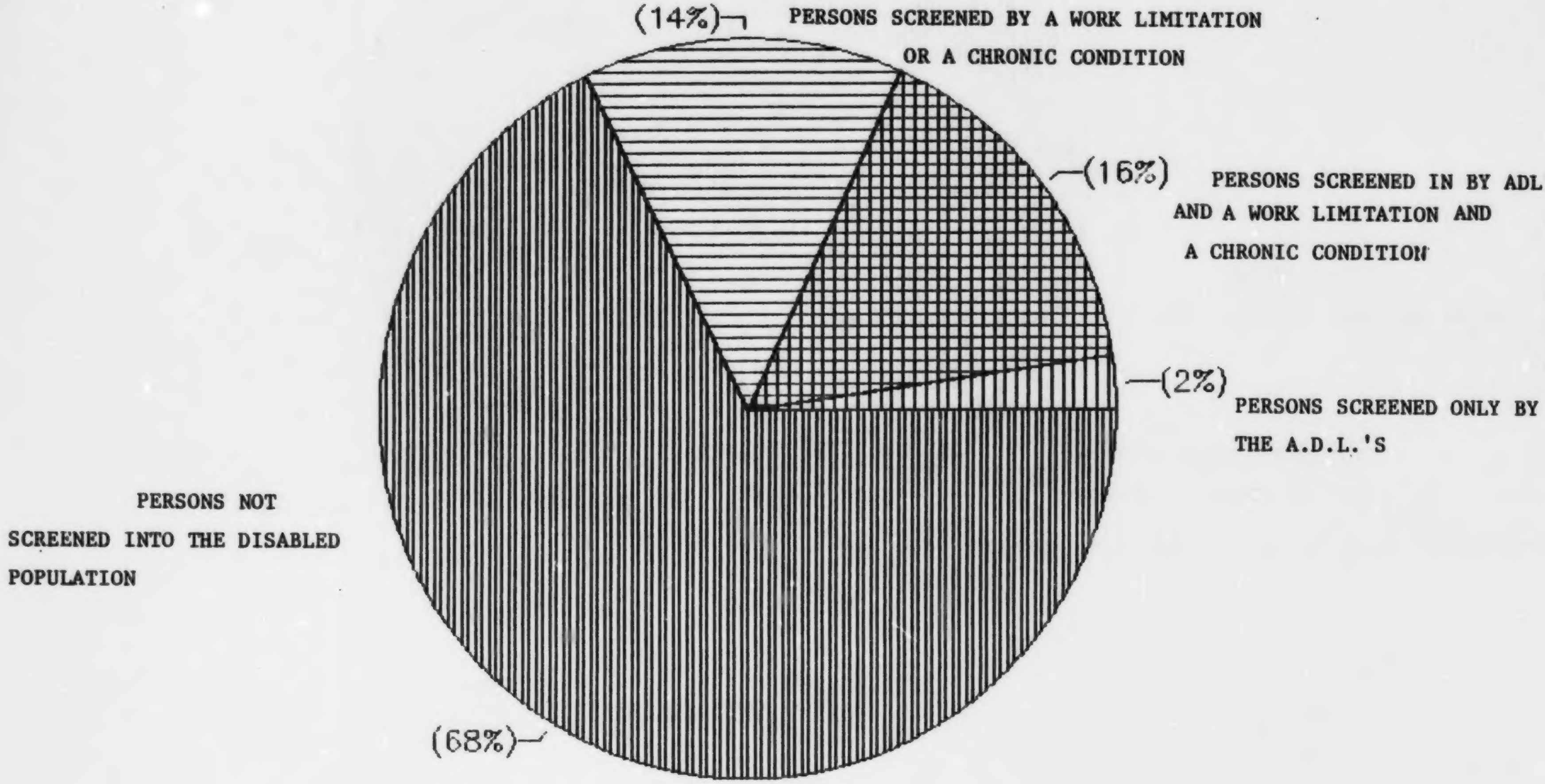


FIGURE 3

PERCENTAGE OF POPULATION SCREENED

TEST 3



5) A single question did not yield the appropriate population and was rejected as a screen device.

Operational Considerations

One of the major problems encountered in the tests with the use of A.D.L.'s as a screening device was that it provided no indication as to the degree of severity of the condition. For example an individual who suffered from tennis elbow might be screened into the target population for the follow up survey. The lack of a severity indicator for the A.D.L.'s is, in and of itself, not a major problem with the screening procedures; however, its absence does create some problems at the time of the follow-up interview. The problems at the time of the follow up are created because persons with minor conditions tend not to respond to the more detailed follow-up questions.

Children present a unique set of operational problems in the screening process. The A.D.L.'s can only be utilized as a screen for populations over the age of approximately ten years old. The daily activities described in the A.D.L.'s are for the most part not applicable to very young children. Statistics Canada was forced to develop a special screening mechanism to determine disability among young children.

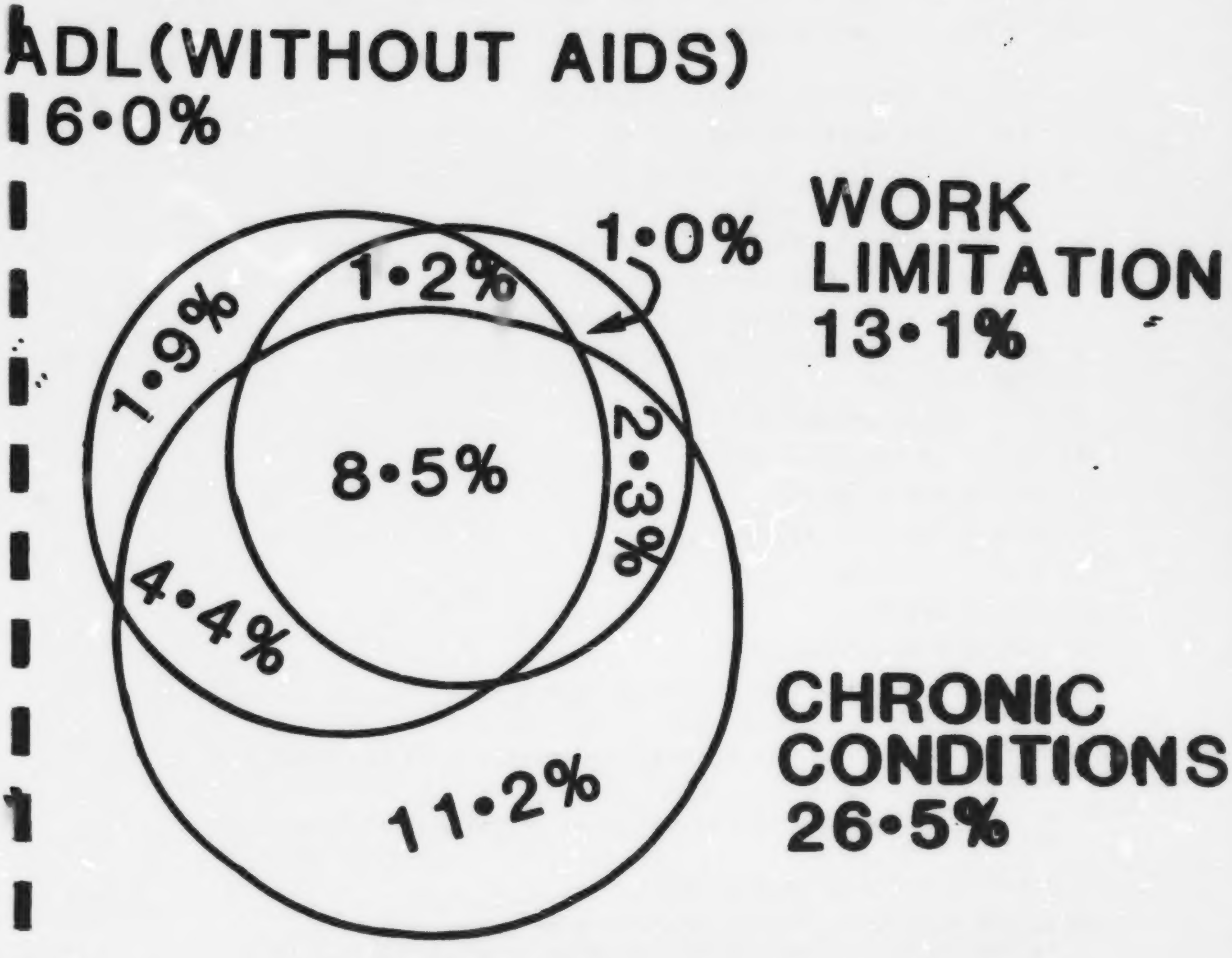
It was determined that because of the length, complexity and possible sensitivity of the questions on the follow-up interview, a personal interview was the most appropriate collection method for persons screened into the target population. In addition, a review of other research in the area of collection of disability data showed that telephone interviews were not acceptable data collection methods. Telephone interviews were ruled out because of obvious problems for persons who are hearing impaired or who are deaf. In addition, studies of elderly populations have indicated that certain response problems were encountered when surveys were conducted over the telephone. These problems are further enumerated in INTERVIEWING OLDER ADULTS: A COMPARISON OF TELEPHONE AND FACE TO FACE MODALITIES (Hertzog and Rodgers) in Public Opinion Quarterly. (vol 47: 405-418).

Although it was Statistics Canada's experience that the A.D.L.'s screened a population close to the definition of disabled, they present the researcher with several operational concerns. The major problem with the use of the A.D.L.'s as a screening mechanism is the requirement that seventeen questions be posed to each respondent in the population in order to determineif the person belongs in the target population. This is a particular problem when posing the questions to very healthy respondents. Debriefing reports from interviewers after the administration of Tests Two and Three indicated some reluctance on the part of respondents to answer the full set of A.D.L.'s. Despite their effectiveness as a screen mechanism the drawback of the A.D.L.'s would seem to be the amount of burden placed on respondents. A further problem associated with the time required to administer the A.D.L.'s is the cost factor. The increased interview time means increased expenditure on collection costs.

As a result of the analysis of the data from the test, it was determined that the most effective screening mechanism was the A.D.L.'s question set. However, in the analysis of the A.D.L.'s sub sets of the population were screened in by criteria other than the A.D.L.'s. For example, as the venn diagram (Figure 4) for Test Three illustrates, roughly 12% of the population who claimed to have a chronic condition were not screened by the A.D.L. questions. Further, one percent of persons who claimed to have work limitations were screened by neither the A.D.L. nor the chronic condition questions. As mentioned earlier, analysis of the chronic condition data showed a large portion of those persons who were identified as having chronic condition fell outside the scope of the definition of disabled. (eg. allergies or mild high blood pressure). Despite this fact, it was felt that there were some small sub sets of these populations not screened by the A.D.L.'s who should have been a part of the target population. In order to account for these persons it was deemed appropriate to develope a single "catch-all"

FIGURE 4

TEST 3


ADL(WITHOUT AIDS)
16•0%
WORK
LIMITATION
13•1%
CHRONIC
CONDITIONS
26•5%
1•9%
1•2%
1•0%
2•3%
8•5%
4•4%
11•2%

TOTAL SCREENED IN: 30•6%

TOTAL SAMPLE SIZE: 37,743

question to enhance the screening capabilities of the A.D.L. question set. Thus the final screening mechanism developed by Statistics Canada was a set of 18 Activities of Daily Living questions and a single "catch-all" question, the final A.D.L. questions and the catch-all question that made up the final screening mechanism are described below.

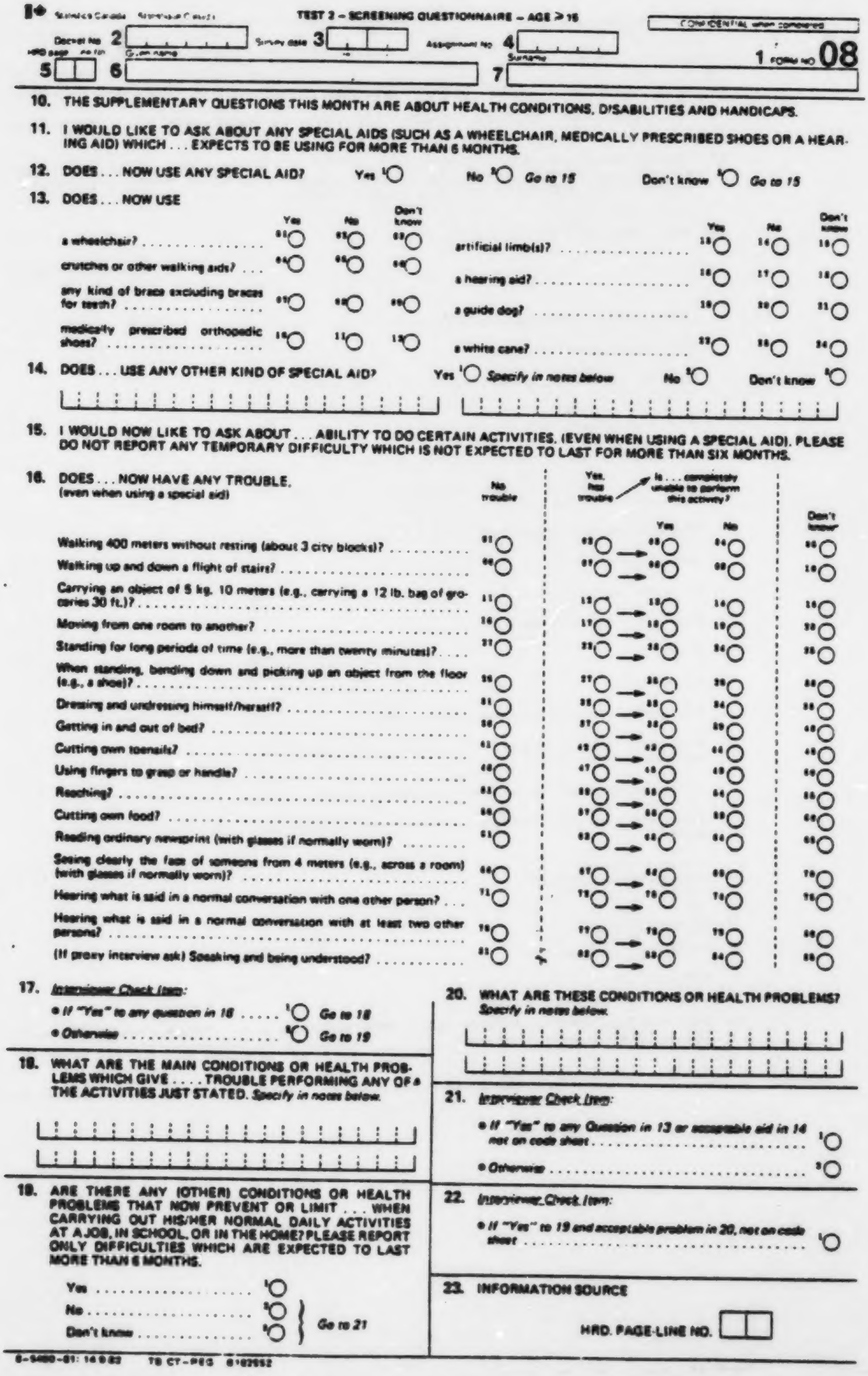
Does the respondent have any trouble -

1) walking 400 metres without resting
2) walking up and down a flight of stairs
3) carrying an object of 5 kg. 10 metres (a 12 lb. bag of groceries 30 feet?)
4) moving from one room to another
5) standing for long periods of time (more than 20 minutes)
6) when standing, bending down and picking up an object from the floor
7) dressing and undressing
8) getting in and out of bed
9) cutting own toenails
10) using fingers to grasp or handle
11) trouble reaching
12) cutting own food
13) reading ordinary newsprint
14) seeing clearly the face of someone from 4 metres (across a room, with glasses if normally worn)
15) hearing what is said in a normal conversation with one other person
16) hearing what is said in a normal conversation with at least two other persons
18) speaking and being understood
19) Is the respondent limited in the kind or amount of activity he/she can do at home, at work or going to school because of a long-term physical condition or health problem?

Acknowledgements

The author would like to acknowledge the assistance of Mr. J.-P Morin who helped prepare some of the data presented in the paper. The author would also like to acknowledge the use of material from internal Statistics Canada working documents prepared by Mr. D. Dolson and Mr. P. Giles. The opinions expressed are those of the author and may not necessarily be the views of Statistics Canada.

Appendix A



Statistics Canada Statistique Canada

TEST 2 – SCREENING QUESTIONNAIRE – AGE ≥ 15

CONFIDENTIAL when completed

Docket No. 2 ☐ Survey date 3 ☐ Assignment No. 4 ☐

HRD page no./ln 5 ☐ Given name 6 ☐ Surname 7 ☐

1 FORM NO. 08

10. THE SUPPLEMENTARY QUESTIONS THIS MONTH ARE ABOUT HEALTH CONDITIONS, DISABILITIES AND HANDICAPS.

11. I WOULD LIKE TO ASK ABOUT ANY SPECIAL AIDS (SUCH AS A WHEELCHAIR, MEDICALLY PRESCRIBED SHOES OR A HEARING AID) WHICH . . . EXPECTS TO BE USING FOR MORE THAN 6 MONTHS.

12. DOES . . . NOW USE ANY SPECIAL AID? Yes 1○ No 2○ *Go to 15* Don't know 3○ *Go to 15*

13. DOES . . . NOW USE

	Yes	No	Don't know		Yes	No	Don't know
a wheelchair?	01○	02○	03○	artificial limb(s)?	13○	14○	15○
crutches or other walking aids?	04○	05○	06○	a hearing aid?	16○	17○	18○
any kind of brace excluding braces for teeth?	07○	08○	09○	a guide dog?	19○	20○	21○
medically prescribed orthopedic shoes?	10○	11○	12○	a white cane?	22○	23○	24○

14. DOES . . . USE ANY OTHER KIND OF SPECIAL AID? Yes 1○ *Specify in notes below* No 2○ Don't know 3○

15. I WOULD NOW LIKE TO ASK ABOUT . . . ABILITY TO DO CERTAIN ACTIVITIES, (EVEN WHEN USING A SPECIAL AID). PLEASE DO NOT REPORT ANY TEMPORARY DIFFICULTY WHICH IS NOT EXPECTED TO LAST FOR MORE THAN SIX MONTHS.

16. DOES . . . NOW HAVE ANY TROUBLE,
(even when using a special aid)

	No trouble	Yes, has trouble	Is . . . completely unable to perform this activity?		Don't know
			Yes	No	
Walking 400 meters without resting (about 3 city blocks)?	01○	02○ →	03○	04○	05○
Walking up and down a flight of stairs?	06○	07○ →	08○	09○	10○
Carrying an object of 5 kg. 10 meters (e.g., carrying a 12 lb. bag of groceries 30 ft.)?	11○	12○ →	13○	14○	15○
Moving from one room to another?	16○	17○ →	18○	19○	20○
Standing for long periods of time (e.g., more than twenty minutes)?	21○	22○ →	23○	24○	25○
When standing, bending down and picking up an object from the floor (e.g., a shoe)?	26○	27○ →	28○	29○	30○
Dressing and undressing himself/herself?	31○	32○ →	33○	34○	35○
Getting in and out of bed?	36○	37○ →	38○	39○	40○
Cutting own toenails?	41○	42○ →	43○	44○	45○
Using fingers to grasp or handle?	46○	47○ →	48○	49○	50○
Reaching?	51○	52○ →	53○	54○	55○
Cutting own food?	56○	57○ →	58○	59○	60○
Reading ordinary newsprint (with glasses if normally worn)?	61○	62○ →	63○	64○	65○
Seeing clearly the face of someone from 4 meters (e.g., across a room) (with glasses if normally worn)?	66○	67○ →	68○	69○	70○
Hearing what is said in a normal conversation with one other person?	71○	72○ →	73○	74○	75○
Hearing what is said in a normal conversation with at least two other persons?	76○	77○ →	78○	79○	80○
(If proxy interview ask) Speaking and being understood?	81○	82○ →	83○	84○	85○

17. *Interviewer Check Item:*
- *If "Yes" to any question in 16* . . . . . 1○ *Go to 18*
- *Otherwise* . . . . 2○ *Go to 19*

18. WHAT ARE THE MAIN CONDITIONS OR HEALTH PROBLEMS WHICH GIVE . . . . TROUBLE PERFORMING ANY OF THE ACTIVITIES JUST STATED. *Specify in notes below.*

19. ARE THERE ANY (OTHER) CONDITIONS OR HEALTH PROBLEMS THAT NOW PREVENT OR LIMIT . . . WHEN CARRYING OUT HIS/HER NORMAL DAILY ACTIVITIES AT A JOB, IN SCHOOL, OR IN THE HOME? PLEASE REPORT ONLY DIFFICULTIES WHICH ARE EXPECTED TO LAST MORE THAN 6 MONTHS.

Yes . . . . 1○
No . . . . 2○ } *Go to 21*
Don't know . . . . 3○ } *Go to 21*

20. WHAT ARE THESE CONDITIONS OR HEALTH PROBLEMS? *Specify in notes below.*

21. *Interviewer Check Item:*
- *If "Yes" to any Question in 13 or acceptable aid in 14 not on code sheet* . . . . 1○
- *Otherwise* . . . . 2○

22. *Interviewer Check Item:*
- *If "Yes" to 19 and acceptable problem in 20, not on code sheet* . . . . 1○

23. INFORMATION SOURCE

HRD. PAGE-LINE NO. ☐☐

8-5400-81: 14.9.82 TB CT-PEG 8182552

Statistics Canada Statistique Canada

TEST 3 – SCREENING QUESTIONNAIRE – AGE ≥ 15

CONFIDENTIAL when completed

Docket No. 2 ☐ Survey date 3 ☐ Assignment No. 4 ☐

HRD page - line No. 5 ☐ Given name 6 ☐ Surname 7 ☐ 1 FORM NO. 10

10. THE SUPPLEMENTARY QUESTIONS THIS MONTH ARE ABOUT HEALTH CONDITIONS, DISABILITIES AND HANDICAPS.

11. I WOULD LIKE TO ASK ABOUT . . . ABILITY TO DO CERTAIN ACTIVITIES WITHOUT THE USE OF ANY SPECIAL AID, SUCH AS A WHEELCHAIR, MEDICALLY PRESCRIBED SHOES OR A HEARING AID. DO NOT REPORT ANY TEMPORARY DIFFICULTIES WHICH ARE NOT EXPECTED TO LAST MORE THAN SIX MONTHS.

12. DOES . . . NOW HAVE ANY TROUBLE,

	No trouble	Yes, has trouble	Is . . . completely unable to perform this activity?		Don't know
			Yes	No	
Walking 400 meters without resting (about 3 city clocks)?	01 ○	02 ○ →	03 ○	04 ○	05 ○
Walking up and down a flight of stairs?	06 ○	07 ○ →	08 ○	09 ○	10 ○
Carrying an object of 5 kg. 10 meters (e.g., carrying a 12 lb. bag of groceries 30 ft.)?	11 ○	12 ○ →	13 ○	14 ○	15 ○
Moving from one room to another?	16 ○	17 ○ →	18 ○	19 ○	20 ○
Standing for long periods of time (e.g., more than twenty minutes)?	21 ○	22 ○ →	23 ○	24 ○	25 ○
When standing, bending down and picking up an object from the floor (e.g., a shoe)?	26 ○	27 ○ →	28 ○	29 ○	30 ○
Dressing and undressing himself/herself?	31 ○	32 ○ →	33 ○	34 ○	35 ○
Getting in and out of bed?	36 ○	37 ○ →	38 ○	39 ○	40 ○
Cutting own toenails?	41 ○	42 ○ →	43 ○	44 ○	45 ○
Using fingers to grasp or handle?	46 ○	47 ○ →	48 ○	49 ○	50 ○
Reaching?	51 ○	52 ○ →	53 ○	54 ○	55 ○
Cutting own food?	56 ○	57 ○ →	58 ○	59 ○	60 ○
Reading ordinary newsprint (with glasses if normally worn)?	61 ○	62 ○ →	63 ○	64 ○	65 ○
Seeing clearly the face of someone from 4 meters (e.g., across a room) (with glasses if normally worn)?	66 ○	67 ○ →	68 ○	69 ○	70 ○
Hearing what is said in a normal conversation with one other person?	71 ○	72 ○ →	73 ○	74 ○	75 ○
Hearing what is said in a normal conversation with at least two other persons?	76 ○	77 ○ →	78 ○	79 ○	80 ○
(If proxy interview ask) Speaking and being understood?	81 ○	82 ○ →	83 ○	84 ○	85 ○

13. *Interviewer Check Item:*

- *If "Yes" to any question in 12* . . . . 1 ○ *Go to 14*
- *Otherwise* . . . . 2 ○ *Go to 15*

14. WHAT ARE THE MAIN CONDITIONS OR HEALTH PROBLEMS WHICH GIVE . . . TROUBLE PERFORMING ANY OF THE ACTIVITIES JUST STATED? *Specify in notes below.*

☐ ☐

8-5400-83.1 14-9-82 TB CT-RKG 8102592

15. *Interviewer Check Item:*

- *on FORM 05, if "Yes" in Item 10 or any code but 6 in Item 33* . . . . . 1○ *Go to 16*
- *Otherwise* . . . . . 2○ *Go to 17*

16. IS . . . LIMITED IN THE KIND OR AMOUNT OF WORK HE/SHE CAN DO AT HIS/HER JOB OR BUSINESS BECAUSE OF A LONG-TERM PHYSICAL CONDITION OR HEALTH PROBLEM?

Yes 1○ *Go to 18* No 2○ *Go to 17* Don't know 3○ *Go to 17*

17. IS . . . PREVENTED OR LIMITED IN THE KIND OR AMOUNT OF WORK HE/SHE COULD DO AT ANY JOB OR BUSINESS BECAUSE OF A LONG-TERM PHYSICAL CONDITION OR HEALTH PROBLEM?

Yes 1○ *Go to 18* No 2○ *Go to 19* Don't know 3○ *Go to 19*

18. WHAT ARE THE MAIN PHYSICAL CONDITIONS OR HEALTH PROBLEMS WHICH CAUSED THIS LIMITATION? *Specify in notes below.*

19. WHICH, IF ANY, OF THESE LONG-TERM CONDITIONS OR HEALTH PROBLEMS DOES . . . PRESENTLY HAVE? PLEASE REPORT ANY CONDITION EVEN IF . . . FEELS IT IS UNDER CONTROL.

	Yes	No	Don't know
Heart disease	01○	02○	03○
Kidney disease	04○	05○	06○
Lung disease	07○	08○	09○
Cancer	10○	11○	12○
Diabetes	13○	14○	15○
Epilepsy	16○	17○	18○
Cerebral palsy	19○	20○	21○
Multiple sclerosis	22○	23○	24○
Cystic fibrosis	25○	26○	27○
Muscular dystrophy	28○	29○	30○
Paralysis of any kind	31○	32○	33○
Arthritis or rheumatism of a serious nature	34○	35○	36○
High blood pressure	37○	38○	39○
Hearing trouble (uncorrected by aid)	40○	41○	42○
Vision trouble (uncorrected by aid)	43○	44○	45○
(If proxy interview ask) Mental handicap	46○	47○	48○

20. DOES . . . HAVE ANY MISSING LIMB(S) INCLUDING FINGER(S) AND TOE(S)?

Yes 1○ No 2○ *Go to 22* Don't know 3○ *Go to 22*

21. WHICH LIMB(S) IS . . . MISSING? *(Mark all that apply)*

	Yes	No	Don't know
Arm(s)	01○	02○	03○
Hand(s)	04○	05○	06○
Finger(s)	07○	08○	09○
Leg(s)	10○	11○	12○
Feet	13○	14○	15○
Toe(s)	16○	17○	18○

22. DOES . . . HAVE ANY OTHER LONG-TERM CONDITIONS OR HEALTH PROBLEMS EXPECTED TO LAST MORE THAN SIX MONTHS?

Yes 1○ *Specify in notes below* No 2○ Don't know 3○

23. *Interviewer Check Item:*

- *If "Yes" in Question 16 or 17 and acceptable problem in Question 18, not on code sheet* . . . . . 1○
- *Otherwise* . . . . . 2○

24. *Interviewer Check Item:*

- *If "Yes" in Question 19 or 20* . . . . . 1○

25. *Interviewer Check Item:*

- *If "Yes" in Question 22 and acceptable problem in Question 22, not on code sheet* . . . . . 1○

26. INFORMATION SOURCE

HRD. PAGE-LINE NO. ☐☐

6–6400–02.1 14 9 83

APPENDIX B

A Description of the Canadian Labour Force Survey

The Labour Force Survey is a monthly household survey carried out by Statistics Canada interviewers in approximately 55,000 households (covering individuals 15 years of age and over) throughout the country. Exclusions are made of the populations in the Yukon and Northwest Territories, residents of Indian reserves, full-time members of the Canadian Armed Forces and inmates of institutions. The exclusion of populations of the Yukon, N.W.T. and Indian reserves is based primarily on operational considerations. Inmates of institutions and full-time members of the Canadian Armed Forces are excluded because they are considered to exist outside the labour market to which the LFS applies.

The LFS employs a stratified multi-stage probability design. For design purposes, each province of Canada constitutes an **independent** sample. The sample is divided into two major parts: self-representing units (composed of all the larger cities) and non-self-representing units (consisting of rural areas and smaller urban centers). The final stage of sampling in the LFS is the selection of dwellings. Information is then collected for every person residing in a selected dwelling; these persons are collectively known as the household.

Each dwelling is retained in the sample for six consecutive months and no substitution of dwellings takes place in the event of a non-response. Further, the entire sample is divided into six representative parts or rotation groups. The rotation of dwellings is carried out so that one-sixth of the sample is changed each month.

Usually the Labour Force Survey (and the supplement) is conducted during the week following the week containing the 15th day of the month. Currently the Labour Force Survey uses 1,200 interviewers operating out of eight regional offices across the country. Interviewing for the Labour Force Survey is done either through a personal visit interview or a telephone interview.

APPENDIX E

Each interviewer contacts approximately fifty designated dwellings and conducts a personal interview in all dwellings where interviews are being conducted for the first time. In larger urban areas, provided the respondent agrees, subsequent interviews may be conducted by telephone. This represents a very brief overview of the LFS design and methodology. More detailed information is available from:

The Guide to Labour Force Survey Data, Catalogue 71-528 or

Methodology of the Canadian Labour Force Survey, Catalogue 71-526.

PUBLIC TRANSPORTATION FOR THE ELDERLY

by Agneta Ståhl

---

1. BACKGROUND

Elderly people are limited in their choice of mode of tranpsort. In a study carried out in Sweden (1) less than 25% were driving a car and about 35% were living in car-owning households. For Sweden, an average of 85% of the population are living in car-owning households. This study also indicated that, when it comes ot the possibility of choosing mode of transport, you can differ between two extremes, almost similar in size - persons having a car in the household and still driving it and persons having no possibility for door-to-door transport, thereby being dependent on public transport.

The two groups mentioned above consist, for the most part, of quite different elderly people. In the group having access to a car and driving it, there is a higher representation of younger elderly (less than 75 years) and of men. These persons are often more healthy and not suffering from physical declines to the same extent as persons belonging to the non-car driving group. There are further indications that it is the oldest female persons, and accordingly those persons with physical disabilities of the normal aging process who are most dependent on public transportation or foot when moving in the environment. The study mentioned above indicated this (see Table 1).

Table 1. Over-representation of the oldest and females in the group most dependent on public transportation (Source 1)

		TOTAL SAMPLE		PEDESTRIANS/BUS USERS	
		MALMÖ (N=619)	SKELLEFTEÅ (N=300)	MALMÖ (N=180)	SKELLEFTEÅ (N=48)
AGE	AGE 65-74	66 % (409)	62 % (186)	52 % (94)	42 % (20)
	75- up	34 % (210)	38 % (114)	48 % (86)	58 % (28)
SEX	MEN	41 % (254)	45 % (135)	27 % (48)	31 % (15)
	WOMEN	59 % (365)	55 % (165)	73 %(132)	69 % (33)

The accessibility to public transportation is limited for many of these people due to difficulties when getting on and off a bus or due to inconveniences when travelling with the bus. Nevertheless, a majority of the elderly use the bus for their daily transportation needs.

When discussing the accessibility to public transports for the elderly and handicapped it is important to take the whole journey into account. The problems experienced among elderly travelling with busses can be divided into four groups:

- problems related to the journey to the bus stop.
  Such problems can be caused by long distances, uneven pavements, slippery pavements, high curbs, sudden steps etc.

- problems related to the bus-stop.
  These are often caused by a lack of shelters and/or benches or badly done snow-cleaning.

- problems related to he exiting/entering of the bus.
  Such problems are often related to the high(first) steps on busses, the design and function of the handrails, the often long distance between the curb and the first step at the stops.

- problems related to the bus journey.
  such problems often are related to the difficulties in having bus stops announced by the driver and the driver's departure from stops (before persons having found a seat).

Making public transportation more accessable to the elderly must be seen as very important in view of the forecasted demographic growth among the eldest persons in Sweden. The age-group 80 years and above is expected to increase in number while approaching the year 2000 while the youngest, aged 65-79, probably will start to decrease in the 1990's. Among the eldest, one is likely to find most persons dependent upon public transportation. Therefore it seems most important to find out what efforts can be made to make public transportation more accessable to the group in society that due to different reasons have no other possibilities to travel. Currently in Sweden, both research and applied studies are being carried out on these problems. This paper focuses upon some projects which the Department of Traffic Planning in Lund has taken part in. But first a few lines about the Swedish policy on transportation for elderly and disabled persons.

2. *SWEDISH POLICY ON TRANSPORTATION FOR THE ELDERLY AND DISABLED*

During the last ten to fifteen years the Swedish government has taken a special interest in elderly and disabled person's transportation problems and possibilities.

To satisfy the transportation needs for those groups having difficulties when travelling by public transports and to a certain extent solve their problems, a special transport system for the handicapped and elderly was established in the beginning of the 1970's. Today every municipality can offer their inhabitants this special transport system after applying and qualifying for a special permit. The person travels either by a specially adapted vehicle or by taxi at a subsidized cost. This permit is mainly meant for persons with quite serious disabilities.

A governmental grant for the cost for this service is given to the municipalities. The rules vary considerably between municipalities concerning the way to judge whether or not a person is qualified for this service and the fare to be paid by the person travelling. The most common rate of payment for the user of the special transport system is 20% of the real price of the journey when using taxicabs. A person haing a special permit is allowed to use the special transport service for almost any purpose.

During the 1980's the costs for this special transport system have increased considerably. About 300.000 persons, almost 4% of Sweden's population, now have a permit for using the special transport system and about 85% of those are 65 years of age or older. This means that approximately 18% of the population in this age-group are travelling with the special transport service. About 95% of the journeys are made by taxicabs. The cost for this service was in the beginning of the 1980's over 700 million SEK and the estimated increase per year is about 10% (2).

Due to both the Swedish policy on disabled persons which is to integrate the disabled into the society to as large an extent as possible and the increasing cost for the special transport service, sincere attempts have now been made in Sweden to improve the public transports to the benefit of elderly and handicapped persons.

In connection with the transport policy, the Swedish Board of Transport was established in 1979 and has, among other things, been given the responsibility for planning, initiating and following up the adaptation of public transport vehicles to a higher level of accessibility.

In early 1982 the Swedish Board of Transport proclaimed their first regulations. This consisted of regulations for busses and other public transports and applied to busses registered from the 1st of January 1984 and forward (3). The policy practised is that busses in urban traffic are not required to be adapted to accomodate a wheelchair, but busses intended for non-urban traffic are.

The Department of Traffic Planning in Lund has been involved in evaluating the benefits of these regulations, including both how far the adaptation has proceeded and any benefits from these regulations for the elderly. A presentation of these regulations and the effects of them, together with two applied studies in this field follows.

3. ONGOING RESEARCH AND APPLIED STUDIES OF NEW BUS SYSTEMS

3.1 Evaluation of the regulations by the Swedish Board of Transport

THE REGULATIONS

The proclamation by the Swedish Board of Transport includes regulations for adaptation of all public transports to the benefit of the elderly. On busses it dictates, among other things,

- the height of the steps; the first step above the road is not to exceed 200 mm
- the width of the doorways; the width of the front door has to be at least 700 mm
- the design and function of the handrails (round or oval form)
- the interior of the bus, including for example, number and placement of seats intended specially for disabled and elderly
- announcing of bus-stops and other information on busses
- the height of figures and letters on destination signs (the height of the figures at the front of the bus must be at least 200 mm)

Even though the proclamation has been known to the bus companies for a few years now and many of the regulations do not require large efforts from the companies, the adaptation has not proceeded very far. An investigation (mail survey) of the adaptation (4) showed that among all the big bus companies in Sweden at least two thirds had started this adaptation. Of these companies which have started adapting, the extent of adaptation varies considerably. For example, the regulations of destination signs (the height of figures and letters) have proceeded farthest together with providing special seats for the deisabled and elderly. More than 50% of the busses of all bus companies are adapted on these points. However it is likely these two questions were interpreted differently, which to a certain extent explains the high figures. For example, the Board's proclamation says there should be some kind of destination sign on both the front, back and side of a bus. It is believed some respondents answered "Yes, we are adapted on that point" when in fact their busses only have destination signs on the front. Another desired adaptation is to make the first step lower (not higher than 200 mm). This has barely started, mostly due to the fact that different technical solutions are still being discussed.

To sum up, the adaptation, according to this study showed that;

- every 4th bus has round or oval handrails
- every 8th bus has handrails marked in contrasting colour
- every 3rd bus has correct destination signs
- every 40th bus has a low first step
- 2 busses out of 3 have seats intended especially for elderly and disabled persons

The company officals also estimated that at most 20% of the bus stops are announced. Usually the drivers do it when they are specifically asked to do so by a passenger.

BENEFITS FOR THE ELDERLY

Method

In order to find out to what extent some of the proclaimed regulations improve the exiting/entering situation for the elderly, a practical experiment was conducted. For the experiment one ordinary bus and one adapted bus were used. Two things were investigated - the importance of a lower step and special designed handrails.(1)

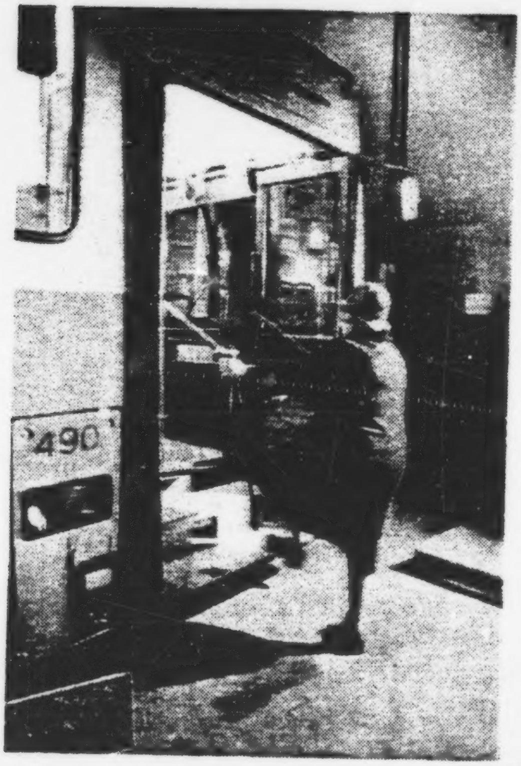
The adapted bus used for the experiment consisted of an extra low step coming out at the bus stop, controlled by the bus-driver (see Picture 1). The height of the first step on an ordinay bus is usually around 300 mm. The inclusion of the extra step not only lowers this first step to 200 mm, but it also means that all the steps can have a height of 200 mm. Having equidistant steps is considered to be the best design for the disabled.

Picture 1

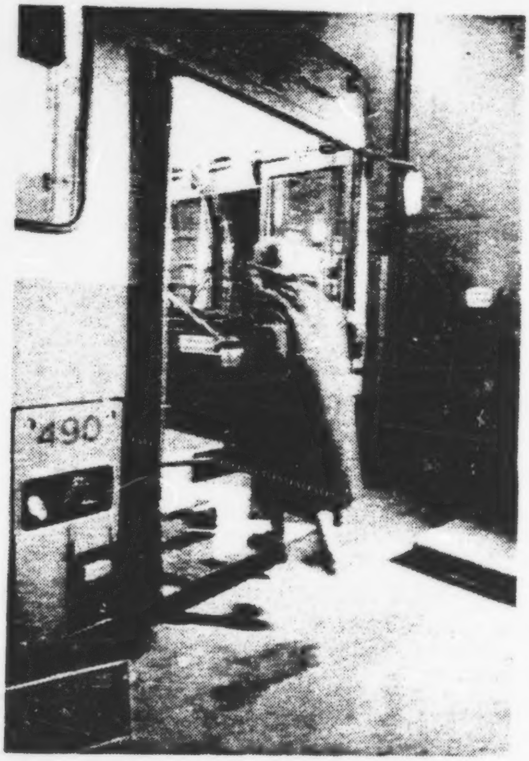
17 persons with various physical declines (in sight or mobility) participated in the experiment. They had also in an earlier study admitted to problems when entering/exiting busses. Each person was entering and exiting both types of busses, first indoors and secondly at different ordinary bus stops. Several photos were taken for each boarding and were analysed afterwards. In addition, a more subjective amount of information was obtained through a brief interview with each subject after their entering/exiting.

Results

The first step (the step above the road) is often the one that causes the most trouble while entering and exiting a bus. When entering the bus a person with some decline in mobility must make a strenuous effort (see Picture 2 and 3), This problem is obviously related to the height of the step.



Picture 2



Picture 3

At ordinary bus-stops the curb often does not give the expected "help" entering the bus. The height of the curb is expected to be at least 100 mm which would decrease the first step to around 250 mm. The real situation however is often to the contrary, see Picture 4.

Picture 4

The height of the curb here is not more than 50 mm. The situation is aggravated due to the fact that the bus does not stop close enough to the curb. This can result in not only a high step but also a "long" diagonal step. The adapted bus makes the entering much easier (see Picture 5 and 6).

Picture 5

Picture 6

Upon entering, no special efforts have to be made in this case. As can be seen in Picture 6, the extra step has another valuable function - it "fills up" the distance between the bus and the curb. The difficulty of stopping close to the curb does not have that importance any longer and the extra "long" step for the elderly is eliminated. Unfortunately another technical solution for the low step (200 mm) has become more popular among the bus companies, namely the kneeling bus. The advantage with the extra step discussed above is lost with the kneeling bus solution.

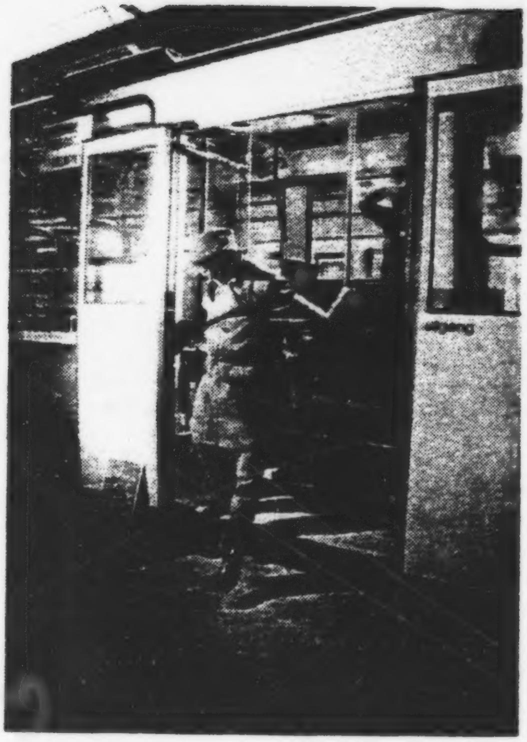
For most elderly with declines in mobility, exiting a bus is more difficult than entering. Contributing causes are the height and the distance between the bus and the curb (see Picture 7).

Picture 7

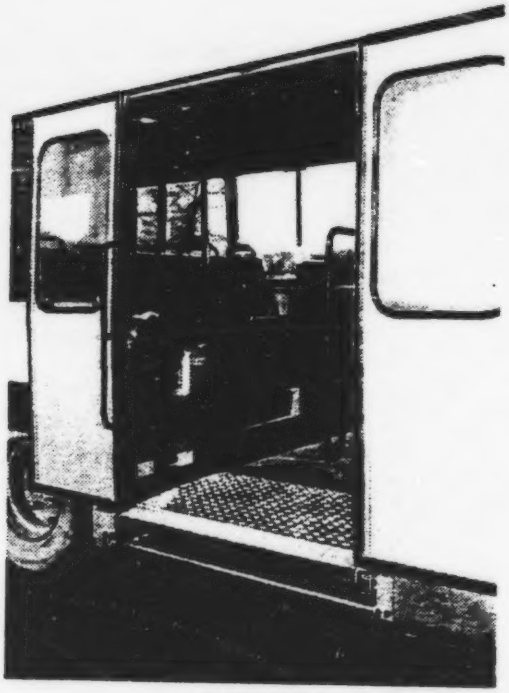
Picture 8

For the bus-driver it is even more difficult to get close to the curb with the back of the bus than with the front. In Sweden, in practise, exiting the bus takes place through the back door. While exiting an extra low step would therefore have even more importance for a person with physical declines (see Picture 8).

The difficulties exiting an ordinary bus are also caused by badly functioning handrails. As can be seen in Picture 7, the handrails are placed too far in from the point of exit. In the situation where the highest need for support is required, i.e., the step down to the curb, the placing of the handrails is not sufficient (see Picture 9). This makes a person dependent on some support, "hanging" in the air with the hands behind the body. This is not suitable. A technical construction where the handrails instead rotate to a position outside the bus (see Picture 10) is a much better solution.



Picture 9



Picture 10

Discussion

An (extra) low step was found most satisfactory to a person with physical declines, both while entering and exiting a bus. The placing of the handrails however, must be further out from the bus to give the right support while exiting.

All persons participating in the experiment found the adapted bus much more comfortable entering and exiting than the ordinary bus. This was mostly due to the low first step and the equidistant height of the steps.

The regulations for busses made by the Swedish Board of Transport are without a doubt beneficial to the elderly and disabled. Unfortunately these regulations only dictate the technical part of the problem; there is another important side of these problems, namely the interpretation and execution of such rules by all parties involved,ie, bus owners, bus drivers and passengers.

From this study it can be argued that in order to give those groups in society who are most unsatisfied when it comes to transport facilities better transportation possibilities, the alternatives must provide a certain security. Therefore it is important that the measures taken to adapt the busses for elderly and disabled persons must include clear instructions about the real-life execution of them. If the use of, for example, such regulations is left solely to the driver's consideration, the security and safety which is so important to those groups who have difficulties travelling by the public transports may be lost.

3.2 *Behaviourial aspects*

As was pointed out in section 3.1, one of the main results from the research concerning adaptation of public transports is that the problems experienced by the elderly and disabled can not solely be solved by technical solutions on the vehicles. There is another important side of the problem, namely behaviourial aspects.

There is a lack of consideration and understanding from both bus-drivers and other passengers concerning acting and driving habits pertaining to the special needs of elderly passengers. In our opinion, such deficiencies in behaviour can be just as problematic for the elderly bus passenger as are technical deficiences on the vehicles.

In order to see if more considerate behaviour from the bus-drivers would make busses more accessable to the elderly, an applied study in one smaller Swedish town (60.000 inhabitants) was carried out and evaluted last winter, 1983/84.(5)

Method

The study was carried out in one geographically defined area. Half the population aged 65 years or more in this area (600 persons) were via a mail survey asked about the public transports in that area, i.e what were their experienced problems and what did they require as a bus passenger.

The bus-drivers driving in that particular area were also interwieved, ie, how did they view the elderly passengers and what are the main problems for an elderly passenger travelling by bus.

From this mail survey with the elderly and the bus-driver interviews, a list of behaviorial measures were selected to be investigated in the actual applied study which followed.

These were as follows:

- the bus-driver will stop closer to the curb
- the bus-driver will not start the bus until the elderly have taken a seat
- the bus-driver will see to it that the seats specially marked for the elderly are free for the elderly
- the bus-driver will announce the bus-stops
- the bus-driver will allow good time at a bus-stop so that the elderly do not have to leave their seat until the bus has stopped at a bus-stop
- the bus-driver will let the elderly exit through the front door

The actual applied study involved two phases. In the first phase, the bus-drivers in the studied area were met personally for one hour and informed about the upcoming applied study - what would be expected of them, (the above listed measures) as well as general information concerning the special needs of elderly bus-passengers. At the same time a special leaflet was sent to all elderly in the area informing them of the applied study, i.e, that for a period of time they could expect "better bus service for elderly". This pamphlet outlined the abovementioned bus-drivers behaviors as well as a statement of good faith from the local bus sompany concerning their elderly passengers.

One week after the above described information campaign, the second phase began which consisted of 6 months of the experimental bus service. One month after this experimental period, all elderly and bus-drivers were again interviewed, the elderly via mail surveys and the bus-drivers personally.

It should be remembered that approximately half of the elderly population in the area were involved in the pre-experimental mail surveys. Since all the elderly were sent the post-experimental survey, there was a chance to gauge the potential effects of being involved in both phases of the study.

Results

Around 50% of the elderly chosen for the study answered that they regularly travelled by the public transports (busses).
In the pre-experimental phase less than 50% admitted to some kind of problems when travelling, while in the post-experimental phase almost 70% of the same elderly admitted to problems. The higher figure in the post-experimental study might be explained by the fact that the elderly then knew the aim of the study and were acquainted with what behaviours could be expected from the bus-drivers. This is supported by those elderly just sent the second survey who to a similar extent admitted to problems.

What follows below are some details focusing on the comparisions between the pre- and post- experimental surveys and the comparision between the elderly who were sent both the pre- and post-experimental mail surveys (called Group 1) and the elderly who was only sent the post-experimental survey (called Group 2).
The post-experimental survey included apart from questions if they admitted to certain problems, also a question about whether they thought improvements had taken place (during the 6 month experimental period) regarding the specific problems being investigated.

- Concerning entering the bus about 40% of all elderly found this easier during the experimental period. This was mainly due to the bus stopping closer to the curb or that the snow-cleaning was better conducted at the bus-stops. The elderly also found themselves less stressed entering the bus.
  Between the two groups, Group 2 (only sent the post-experimental survey) seemed to be a bit more positive than Group 1. There were some differences though between the groups concerning their reason for experiencing improvements while entering the bus. For

example, Group 2 pointed more towards improved snow-cleaning while Group 1 cited to a greater degree stopping closer to the curb. This is worth mentioning because perceived improvements may often be attributed to different factors even within a similar group of people.

- Concerning exiting the bus the uncertainess concerning the opening/closing of the backdoor was somewhat less during the experimental period. In the both groups in the post-expermental survey about 30% admitted to improvements concerning this factor.

- Measures taken during the bus-journey also showed perceived improvements for the elderly during the experimental period.
  More than 50% of all elderly reported that they usually used the seats specially marked for the elderly. Many said however, they could not use them due to other persons having taken those seats. It appeared the drivers had a harder time executing this particular measure.

  During the experimental period 50% of the elderly in both group 1 and 2 answered that the driver now never left the bus-stops until they had taken a seat, compaired to 30% in the pre-experimental survey (Group 1 only). Concerning this factor, 60% of all the elderly in the post-experimental survey reported improvements.

  Concerning the opportunity to remain seated until the bus has stopped at a bus-stop, it appeared that this measure was not as effectively executed. About 20% of the elderly answered that they, during the experimental period, always had to get up from the seat before the bus stopped. This was also the case in the pre-experimental survey (only Group 1) where 20% also reported they had to get up before the bus stopped at a bus-stop. In this case the drivers are not solely to blame. Many elderly are very anxious to rise in good time, which can not be helped by the driver's behaviour. Even so, almost 40% of all the elderly perceived improvements concerning the opportunity to remain seated.

  The desire to have the bus-stops announced was higher for the elderly (Group 1) after the experimental period. This fact was supported by Group 2 who also reported a similar desire in the post-experimental survey. Thus, 90% of the elderly reported this desire.

- On the general question whether the elderly found it easier to travel during the experimental period than before, almost 60% in both groups answered "Yes it was" and 15% of these reported improvements to a great extent.

Discussion

First of all it can be said that the attitudes among most elderly and bus-drivers concerning the experimental period seem to be positive.
Concerning the bus-drivers it seems to be most important to motivate them regarding the special qualifications of the elderly. In many situations it might be the lack of understanding of the problems of the elderly that create their behaviour. To what extent all measures really were carried out by all bus-drivers is difficult to say. In the interviews after the experimental period, most drivers, showed a positive attitude when asked to what extent they had been

able to carry out the measures. Thus, most of the drivers answered they had been doing it frequently and were still doing so.

The execution of one measure however leaves much to be desired, namely the announcing of the bus-stops.
This is an important service to all passengers travelling by bus, especially during the long dark season in this country. The bus-drivers don't seem to want to do this and find all reasons thinkable for not doing it, for example, "announcing the bus-stops requires too much attention and can therefore be a traffic safety problem".

The results from the post-experimental survey with the elderly also seemed to confirm the problems concerning announced bus-stops. This was the only behaviorial measure where the elderly's desire was higher after the experimental period than in the pre-experimental survey. Other perceived problems seem to have decreased among the elderly and they also admitted to various improvements concerning the experimental bus service. Even so it seems reasonable to expect even more from the drivers related to the problems experienced by the elderly.

If the bus travelling situation is to be beneficial for the elderly it is most important to instill a degree of security in them, ie they should be able to expect a regular execution of the measures discussed in the present study. The best way of achieving this is by effectively motivating the drivers; making them aware in a sensitive way to the special needs of the elderly using public busses. Such a motivation is a complex task which obviously involves many factors - the personality of the driver, his sympathetic understanding of the elderly, the particular environmental circumstances of the bus journey (number of passengers, weather, etc) and last but not least the attitude towards the elderly taken by the bus companies who have the authority to make such demands upon their drivers.
Nevertheless, the conclusion from this study must be that the travelling situation for the elderly is possible and practical to improve through behaviourial measures.

3.3 *Volvo's new city bus system in Halmstad*

Lastly, a new city bus system in Sweden will be presented.

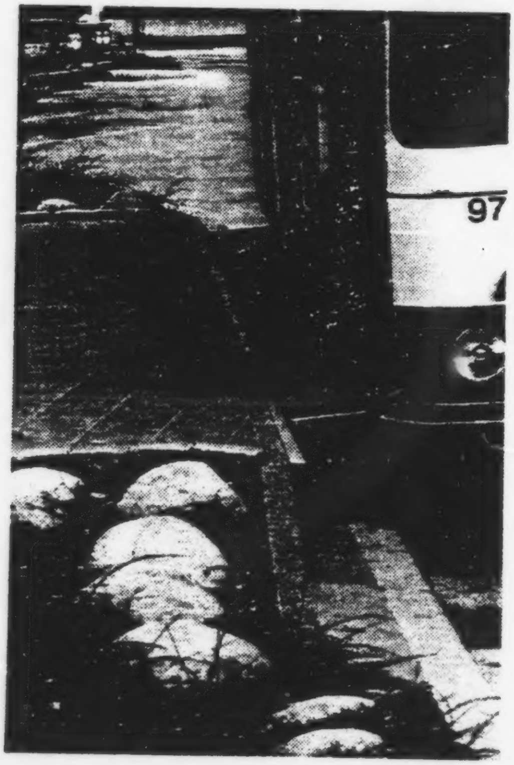
Since 1979 a new bus system in one Swedish town consisting of leveled platforms and specially built vehicles has been in operation. A short presentation of this bus system is made in this section in order to exemplify a very specific way of making the busses more accessable to the elderly and disabled.

PRESENTATION OF THE BUS SYSTEM

(From a brochure made by Volvo Bus Corporation in 1980 (6))

The introduction of the new Volvo city bus system in Halmstad, a middlesized town in Sweden, on November 28, 1979 was a world premiére. It was the first time a traffic system of this type had ever been put into operation in a town. In co-operation with Chalmers University of Technology in Gothenburg, The Swedish Board for Technical Development (STU) and the municipal authority in Halmstad, Volvo has built up a system which, in this primary phase, consists of eight busses and 25 stops on one route.

The technical advances are based on more than four years of developmental work and the new bus system includes many interesting features. It consists not only of the vehicle but also level bus stops (see Picture 11). The new bus can be used at ordinary bus stops and is not limited to the new system.



Picture 11

The new system is based on the Volvo B 10 R city bus with a single-level floor at the entrance and exit - inconvenient steps and depressions in the floor have been done away with. The bus drives closely up to a bus-stop of the same height as the floor of the bus itself, meaning that prams (baby carriages) and wheelchairs can be wheeled directly on and off. Mounting and alighting are therefore quicker and more convenient for all concerned (see Picture 12).

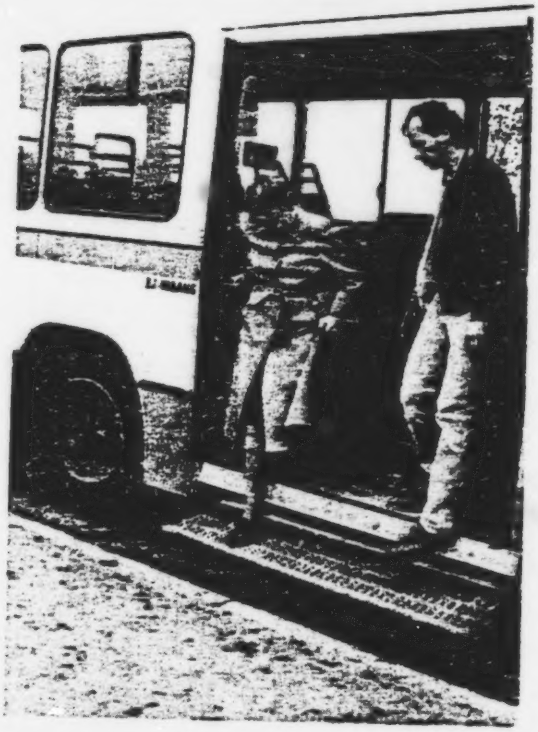
Picture 12

The large area in the centre of the bus in designed for half-sitting or half-standing passengers, more prams (baby carriages) or a wheelchair.

The requirements and desires of the passengers themselves were given first priority in designing the new bus system. Since Volvo's ambition was to produce a public transport system technically acessable to everybody, this philosophy was one of the guidelines in its development. Even those who are suffering from some form of physical handicap should be able to catch a bus, even some of those at present confined to wheelchairs. This is now possible in Halmstad.

In order to allow the bus to stop at exactly the right spot by the bus-stop, Volvo have developed an electronic system aiding steering and braking. This facilitates the driver's task and allows him to concentrate on his passengers and the rest of the traffic. The driver can change over to manual steering and braking at any time without having to take any special measures should the situation so demand. Today the drivers only use the manual system, which has turned out to be sufficient.

An important consideration in designing the new bus was that it should be able to use both the new, high type of bus stop and the more conventional types of stop found in other public transport systems today. When the bus stops at a conventional bus-stop a retractable step is automatically turning out from below the floor as soon as the doors are opened (see Picture 13).



Picture 13

At level bus-stops the bus stops about 40 cm from the high-level bus stop. As soon as the driver activates the door-opening mechanism a platform is moved out from under the bus and the doors are opened. If the bus stops at a conventional (low) bus-stop a step is folded out instead, giving the same entrance height as in the standard city bus (B 10 R). The steps inside the bus have been done away with, meaning that the space available for standing passengers is now greater than in earlier models.

The platform moved out from under the bus is of the sliding ladder type to avoid the danger of becoming blocked by small stones or snow. Both the platform and the retractable step are housed under the floor of the bus between stops.

The wide doors, operated by a photoelectric cell, are fitted with sensor-type edging to avoid passengers being hurt by the door; and both the new platform and the newly designed step are equipped with a special load-detector hindering retraction while a passenger is standing on them. They, too, have been fitted with sensors in their edging in order to prevent injury should anyone be in the way when they are moved out from under the bus.

The bus is unable to move off until the doors are closed and the platform or entrance step has been moved back into place under the bus.

THE WORKING OF THE BUS SYSTEM 1984

The bus system in Halmstad has now been operating for almost 5 years. The system is mainly operating in one newly built residential area where most of the leveled platforms are situated at one special bus route in this area. A few such platforms are also built in the centre of the town.

As an extension of the bus system during the summer 1984, twenty-six new platforms are being built, mainly in established areas in the centre of the town. New busses have also been delivered and in 1984 twenty-one busses are operating.

It is rather common when new equipment is put into operation that mixed feelings and attitudes are expressed among people using and operating the system. This was also the case in Halmstad both among passengers and bus-drivers. Among bus-drivers, for example, there was a strong negative attitude towards the automatic steering and braking system. The busses are today functioning with manual braking and steering at the leveled bus-stops. Among the passengers using the new busses a feeling of unsafety was developed mainly due to a fear of unsteadiness of the platform and the automatic opening system for the door.

The municipality of Halmstad therefore asked for an evaluation of the system which was made in 1983 (7). The evaluation included:

- a passenger survey (about 1.000 persons)
- an experiment including video-recording analyses of embarkment and disembarkment of 18 persons (disabled and/or elderly)
- bus-driver interviews (57 drivers)

The conclusion of this evaluation was as follows:

High-level platforms simplify to a great extent embarkment and disembarkment for elderly, handicapped and persons with children and/or prams. This is the result from both the passenger interviews and the experiment.

At ordinary bus-stops problems when embarking and disembarking are more usual. The new Volvo has showed no greater differences compared to an ordinary bus.

A majority of the drivers were positive towards the goals intended by special platforms. Totally, there were as many drivers positive towards the Volvobus as were negative. The main reason cited for disliking the busses was the disfunctioning of the automatic systems. On the new busses delivered in 1984, improvements on the automatic systems still used have been made.

4. CONCLUDING REMARKS

The importance of public transportation for the elderly is clear. The quality of public bus service can have a major impact on the quality of an elderly person's life. The bus can be the major factor affecting an aged person's involvement in recreational activities, social and family contacts and for many, that walk to and from the bus stop may be their daily exercise.

In Sweden, elderly persons are one of the largest "special needs" groups using the bus. Their special needs as a bus passenger for the most part stem from the effects of physical declines in older age. Fortunately, these special needs have now been studied and we have a fairly good picture of what problems are most critical for the elderly bus traveller; many of these problems were discussed in the present paper with an emphasis on the whole bus trip.

When investigating the elderly using public busses, one must take into account their getting to the stop, shelters and benches at the stop, entering the bus, finding a seat, announcing of the stops, and lastly the all important exit from the bus. Since we are now aware of the problems, the next obvious step is to find and execute suitable solutions for these problems. The present paper highlighted some of the efforts currently being tested in Sweden. There are both "technical" and "behaviourial" aspects to the solution of the elderly's public transport problems.

In our opinion, this technical vs. behaviourial issue is the most critical and demands more careful research. The entire situation can not be adequately solved by technical means - many of the problems which seem entirely technical at first glance, e.g. the inclusion of a lower first step, turn out to have a very important behaviourial component, namely in their proper execution.

We feel there is much to be gained from emphasizing improved behaviour on the part of the bus driver. Behaviourial changes in the drivers are not only practical economically, such changes have other important implications upon the psychological qualities of the elderly person's experience as a bus passenger i.e., increased security, better safety, maybe even subtle benefits such as feelings of increased self-worth. A good next step is to study carefully the best way to incorporate such behaviourial changes into the bus driver's training.

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CANADIAN DEVELOPMENT IN VEHICLE TECHNOLOGY FOR TRANSPORTATION OF THE PHYSICALLY HANDICAPPED

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for

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CANADIAN DEVELOPMENTS IN VEHICLE TECHNOLOGY FOR TRANSPORTATION OF THE PHYSICALLY DISABLED

Introduction

For years the major barrier to integration of physically disabled persons was the difficulty in making a journey: consequently accessibility to "line haul" aspects of transportation systems has been the focus of considerable attention. The net result of these efforts is that the weak link is now, more often than not, in the access, egress and ancillary modes. Improvement to these modes might not be viewed to be as glamorous as improvements done to aircraft, buses and rail coaches but they are nevertheless the necessary elements towards total accessibility.

This paper describes the concept of a complete mobility continuum, and outlines developments, both in vehicle development and related systems research, that have been undertaken in Canada. A direction for future research is proposed.

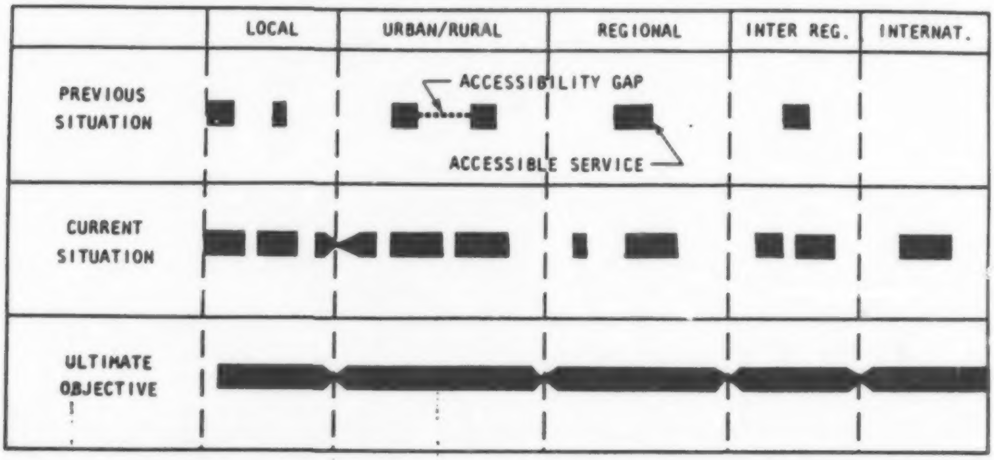
The Concept of Complete Accessibility

To date, efforts in improving existing transportation systems for the physically disabled have tended to adopt a somewhat disjointed "vehicle specific" rather than a systemwide approach. While complete accessibility has indeed been attained on certain vehicles, system implementors were often disappointed by infrequent utilization. The throughput of a transportation system is limited by the capacity of its weakest link which, under present situations, generally is the access, egress and transfer modes. The words "access" and "accessibility" have generally been interpreted with a very limited spatial and temporal implication: a fully accessible bus, to most people, is one which a handicapped person can board and alight. There is very limited value in providing an accessible bus, if access to the vehicle, and not only onto the vehicle, is not provided. The provision of this expanded access may be considerably more difficult than the technological solutions required in providing access onto the vehicle, and may require integration of efforts from many sectors. Accessibility must be thought of in terms of the entire transportation system, origin to destination, rather than segmentally.

Travel for handicapped persons, as for everyone else, can be considered to generally start at home. Mobility actually within the home can often be the first hurdle. Elimination of building barriers is a prerequisite prior to attempting to solve sequential barriers encountered in making a journey. Access to and from transit or simply traversing a street are obvious transportation hindrances. One attempt at alleviating this problem has been the provision of curb cuts in many urban areas. This solution to overcome level change does not however address the associated problem of distance, and curb cuts are of limited value in instances where long distances must be overcome for transit access. Complete accessibility must include urban short distance trips as well as the progressively longer trips including intercity, interregional (national) and international.

To illustrate this point further, it is inappropriate to expend funds solely making, for example, intercity coaches accessible while the bus terminal is not architecturally accessible or that smaller intermediate stations/stops are not equipped to handle a wheelchair passenger. Graphically a trip resembles a series or links of various strengths forming a chain: the week links are the current barriers to the successful continuation of the journey. Complete accessibility means that all links in the chain must be of equal strength. The previous situation, current and ultimate are depicted in Figure 1.

FIGURE 1
DIAGRAMATIC REPRESENTATION OF ACCESSIBILITY GAPS


LOCAL
URBAN/RURAL
REGIONAL
INTER REG.
INTERNAT.
PREVIOUS SITUATION
ACCESSIBILITY GAP
ACCESSIBLE SERVICE
CURRENT SITUATION
ULTIMATE OBJECTIVE

This diagram shows that there are still gaps in all of the trip types to be overcome; however the urban/rural trips are probably the closest to attaining complete accessibility, the ultimate objective.

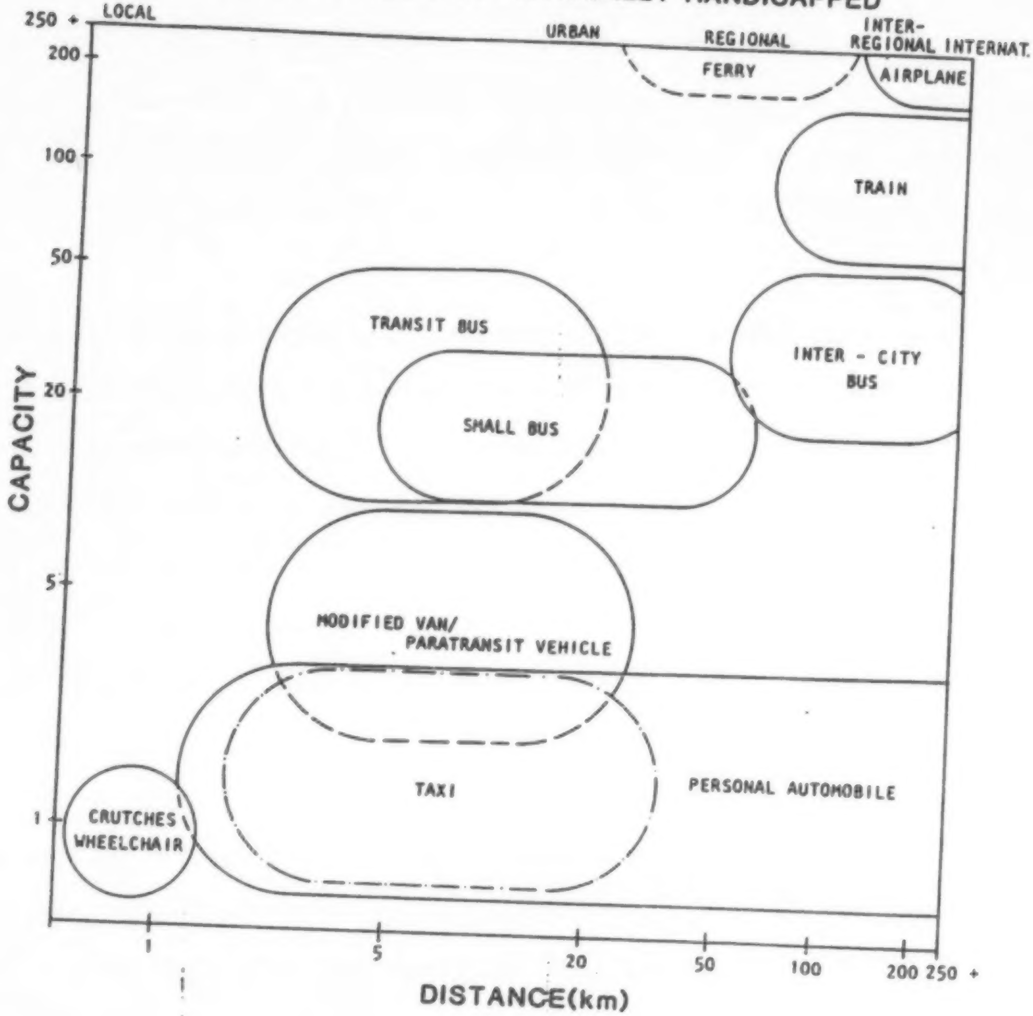
Typology of Vehicle Technology

Developments in vehicle technology have generally addressed line haul functions of the particular mode, whether long or short distance, paying specific attention of access and egress to/from the specific vehicle. Until recently, significantly less attention had been given to the transfer function from one mode to another, resulting in a discontinuous series of more or less accessible modes.

The travel mode used by the physically handicapped obviously varies as a function of distance. Similarily, vehicle capacity varies with distance, the capacity increasing as distance increases. A diagramatic presentation of the interrelationship between distance and capacities, in terms of travelmode, is shown in Figure 2. It will be noted that the personal automobile exhibits considerable flexibility of use, however, because it is considered a "private" or "individual mode", not much attention has been paid to it in terms of government Research and Development.

A further classification of vehicles can be made on the basis of trip type and capacity. There is a relationship between the three capacity groupings (individual, collective and mass) and jurisdiction. It is suggested here that there is a correlation between jurisdictional authority and amount of development. Figure 3 indicates vehicle classification by trip type and capacity.

FIGURE 2
RELATIONSHIP OF CAPACITY & DISTANCE
IN TRAVEL MODES FOR PHYSICALLY HANDICAPPED



Significant research in recent years has concentrated on mass transportation and its accessibility. In the United States the issue regarding federal legislation of transit vehicle accessibility has focused attention on this area. Along with transit vehicles, research funds, both in Europe and North America, have also been expended on smaller vehicles, from small buses to a wide range of paratransit vehicles. Significantly less attention has been paid to individual travel modes. At the other extreme, political pressure has had a

FIGURE 3 **VEHICLE CLASSIFICATION**

		CAPACITY/JURISDICTION		
		INDIVIDUAL	COLLECTIVE	MASS
TRIP TYPE	LOCAL	WHEELCHAIR (manual) WHEELCHAIR (electric) SPECIAL VEHICLE (non-conventional w/c)		
	URBAN/RURAL	SPECIAL VEHICLE AUTOMOBILE	PARA-TRANSIT VEHICLE SMALL BUS MULTI PURPOSE RURAL VEHICLE GROUP VEHICLE TRANSIT BUS	
	REGIONAL	AUTOMOBILE	INTERCITY BUS	TRAIN
	INTER-REG./ INTERNAT.	AUTOMOBILE		TRAIN FERRY AIRPLANE

strong influence in increasing accessibility on major interregional and international modes. Railways and airlines have made considerable improvements in accessibility in many countries. To a certain degree these improvements have not been fully utilized due to weak links in previous segments of the accessibility continuum, however progress in this area is generally commendable.

In Canada the majority of Federal funding has been directed to those travel modes over which jurisdiction is most direct. In addition there has been public pressure exerted to effect improvements in the urban (and to a lesser degree the rural) transportation systems, but there has been less emphasis given to those areas under provincial jurisdiction, and notably little attention paid to individual travel modes. Most developments in this latter category have been the result of entrepreneurial enterprises attempting to fill a perceived market void. The greatest paucity of funding is evident in the transfer modes between line haul functions. This neglected area is commonly a major accessibility barrier in completing a journey. The degree of strength (or weakness) of the various links in the transportation sequence appears to be directly related to the previous allocation of Research and Development funds, which, in turn, has been a function of jurisdictional responsibility.

Canadian Developments

Canada has recently made big strides in increasing accessibility on those modes, such as air, rail and interregional bus, that are federally regulated. These modes are not necessarily, however, the ones most frequently posing a barrier to trip completion, or those offering greatest opportunity for increased trip accessibility. Having made great improvements in many high profile travel modes it has now been noted that the research efforts have been non-uniformly applied. Current research efforts are concentrating more on those travel modes previously neglected which are equally as important in completing the accessibility continuum as the more conspicuous modes. Research effort is now being specifically applied to the weakest links despite a relative lack of jurisdictional responsibility.

A review of selected recently completed or ongoing research is given below.

'Individual' Modes

As previously mentioned, the individual modes have generally been addressed by private enterprise and have benefited only recently from larger sums of public funding. There has, however, been a recent increased awareness of problems and conspicuousness faced at an individual level by physically handicapped persons. This may have led to some of the recent research, such as that conducted at Carleton University on crutches, the basic design and appearance of which has remained relatively unchanged for years.

Canadian development of a curb climbing wheelchair has previously been widely publicized. This development is currently in the hands of a commercial producer and may, demand being sufficient, see mass production in the future.

The Transportation Development Centre of Transport Canada will shortly be commencing research into the wide variety of non-conventional wheelchairs available in the marketplace, and the appropriate licensing and regulatory framework that should be applied. The significant design and performance gap between the wheelchair and the automobile has, in recent years, been filled with many 'vehicles' to which few existing regulations apply. It is important for the safety of all that operating criteria be established that are consistent with the individual vehicles capabilities. This is an issue which other countries must also tackle in the near future.

The ultimate in urban/rural and regional travel flexibility is afforded by the automobile, yet limited efforts at increasing automobile accessibility by physically disabled persons have been made. Canada has recently undertaken a comprehensive evaluation of an English vehicle, the Elswick Envoy, designed to be driven from a wheelchair. The tests conducted were to determine the vehicle's conformity with Canadian Motor Vehicle Safety Standards, but also included an extensive ergonomic evaluation designed to determine the vehicle's suitability as a personal vehicle for Canadian disabled drivers. Research was conducted on access and egress, use of vehicle controls, manoeuvrability, seating, and visibility, using a panel of subjects. A number of specific recommendations resulted from the research. Some of the major ones are:

- redesign of the wheelchair restraint mechanism to accommodate a wider range of chairs;
- incorporate a mechanism for raising and lowering the ramp from outside the vehicle without the current requirement of balance and forward leaning;
- provide an option with power-assisted steering;
- relocate gear selectors;
- provide self aligning feature to guide the wheelchair into the restraint system.

It is hoped that this vehicle, which is now being imported into the United States, will benefit from the extensive testing, both of mechanical systems and ergonomic suitability, and that appropriate modifications will be made to the advantage of the physically disabled community.

Physically handicapped persons that are capable of driving are often severely inconvenienced when away from home by being unable to rent a suitably equipped vehicle. The requirement for a complete set of easily attachable hand controls was identified by Transport Canada as an area of valuable research. As greater numbers of disabled Canadians travel the need for easily installed and removable hand controls for use in rental cars becomes increasingly important. A prototype system has been developed and is now being tested at car rental concessionaires in Ottawa and St. John's, Newfoundland. The system attaches to the brake and gas pedals, the floor and the steering column yoke. Four locking pins permit installation in two minutes and complete removal in less than one minute. It is envisaged that this development, when more widely available, will significantly benefit travellers wishing to utilize rental cars across the country.

Research is currently being undertaken, on behalf of Transport Canada, into vehicle selection guidelines for handicapped persons. More information is needed to assist handicapped people to evaluate the suitability of conventional production automobiles for their personal use. When this research is complete, and the information made available, many persons who previously thought that no vehicle was adaptable to their specific needs may find a suitable and affordable automobile and hence attain greater travel freedom.

'Collective' Modes

Significant attention was paid some years ago in the United States to development of small paratransit vehicles. A Canadian firm, with limited public funding, has made significant advances in this area. The GSM Taxi, a vehicle capable of carrying a wheelchair passenger, was developed by a

Montreal firm. Efforts are currently underway to produce the vehicle in volume and to equip taxi companies across the country with these fully accessible vehicles.

In order that pertinent information might be available to paratransit vehicle regulators, operators, and developers, extensive research was undertaken to provide appropriate guidelines pertaining to these vehicles. It is hoped that dissemination of knowledge of this type will assist in attaining consistent regulations in different jurisdictions, and assist vehicle developers to more accurately meet the market requirements, hence assisting the physically disabled population.

A significant Canadian development that is receiving wide acclaim is the fully accessible small transit vehicle Orion II. This small bus built by Ontario Bus Industries (OBI) of Mississauga, Ontario, supported by the federal Department of Regional and Industrial Expansion, incorporates extensive advanced technology and can carry up to seven wheelchairs with random access. The vehicle is equipped with kneeling suspension and is accessible from both the rear and the side. The Orion II is a sophisticated vehicle and is priced accordingly, however it is less expensive than European vehicles such as Steyr and Neoplan. The Orion has been successful in competitive bidding on a number of recent occassions and is currently being extensively evaluated in service by the State of Michigan.

Research has been undertaken in Canada on accessibility on intercity buses, particularly those under federal regulation, although the technology can equally well be applied to others. In 1981 the Canadian Transport Commission conducted an inquiry into bus service for the disabled in Newfoundland. A subsequent Parliamentary committee recommendation requires that this bus service (Roadcruiser) provide a mechanical system to board wheelchair passengers on Roadcruiser's MC-9 intercity buses.

Transport Canada is committed to a three year demonstration of a MC-9 bus made accessible with the installation of an innovative system developed by the Transportation Development Centre.

A design study to improve the general accessibility of the new intercity articulated bus developed by Prevost Car Inc. included the concept of an internal elevator device. A preliminary engineering study of this 'EL-Lift' system installed in a MC-9 bus determined the initial specifications, and concluded that it was feasible.

Subsequent to a thorough evaluation of the structural changes required, the human factors and engineering design, fabrication, installation and testing of the EL-Lift system are being completed by T E S Limited, Ottawa. The system is hydraulically actuated, incorporates microprocessor technology, and includes a message center to assist the driver in the system's operation and provide limited diagnostics. The T E S Limited design utilizes the space below the lift platform for storage of baggage and includes new restraint units specially designed for intercity buses.

The MC-9 with its EL-Lift system is scheduled to arrive in Newfoundland this November to begin the three year demonstration, the result of which will not only assess this technical solution to bus accessibility problems, but will be used to determine accessibility standards for that sector of Canadian intercity bus transport over which the federal government has jurisdiction.

Transportation for those handicapped persons who live in rural areas has received notable little attention. It is likely that many of those preferring to live in a rural environment have felt compelled to move to urban areas to take advantage of greater mobility options. The practicality, and cost effectiveness, of specialized services in rural areas is severely limited due to the sparse population and greater distances to be traversed. These same problems affect other services, such as provision of ambulance service. In many rural areas the ambulance service, for example, is severaly under-utilized but must still be maintained since no alternative is available. It has been proposed that a multi-purpose vehicle could be used to replace current services that have excess capacity, incorporated with services not currently provided. A vehicle capable of carrying stretchers, wheelchairs and ambulatory passengers could serve a number of roles. The Province of Manitoba is examining the feasibility of such combined services provided by a multi-purpose vehicle. The potential advantages for rural inhabitants in all areas of Canada are significant.

Another area recently investigated in Canada is the question of a group transportation vehicle for the physically handicapped. Currently there are very limited vehicle options available for institutions such as rehabilitation centres, hospitals, group associations, etc., for the handicapped, to transport relatively large numbers of wheelchair passengers. The opportunity for group social/recreational outings is severely limited by unavailability of a suitable vehicle. Vehicles with necessary capacity and equipped with lifts are often unsuitable due to the extensive elapsed time required for loading and unloading large groups of passengers. A comprehensive study was undertaken to determine the advisability of developing a purpose-built group transportation vehicle for wheelchair passengers. It was determined that there were two principal hindrances to this concept: firstly, of the large number of potential users surveyed there was no concensus as to what the optimum vehicle would be in terms of size, features, etc., and secondly, a wide range of financial capability was noted. The conclusion, from the responses, was that no one vehicle type would be appropriate for a sufficient number of users to justify extensive production and to achieve associated economies of scale. What is required is a range of vehicle sizes with emphasis on low cost, but not at the expense of reliability. A modification of the standard school bus was proposed. These vehicles, available in a wide range of sizes, are sturdy, tested and reasonably inexpensive. With appropriate modifications the vehicle need not have the appearance of a school bus but can be made most attractive by means such as window treatments and exterior painting.

'Mass' Capacity

To a large degree developments in this category have been modification to existing vehicles rather than the development of entirely new vehicles. In some instances little more is required than policy decisions to facilitate travel by the physically handicapped. For example, air travel is often accessible to wheelchair passengers, however barriers have been commonplace in terms of pricing structure. Accessibility, although physically possible, may have been denied by other means. Aircraft themselves are generally capable of carrying wheelchair passengers, especially those capable of transfering to an aircraft seat.

Transport Canada is currently funding a study on access to commuter rail services for disabled persons. The study has stemmed from recommendations that all government funded transport equipment be accessible to the physically handicapped. Commuter transportation in Canada has, to date, relied upon parallel services provided by transit operators rather than adopting the integrated approach. Where commuter rail services are available no specific programs have been implemented to either provide a parallel service or to attain accessibility. The research currently underway relates to a partially integrated solution, with some fully accessible vehicles and facilities on selected routes. The research is being undertaken with reference to systems in both Montreal and Toronto.

Attention must be paid not only to the accessibility of the commuter train vehicles, but also to the modal transfers on reaching the station, and accessing the vehicles. It is hoped that this research may present feasible solutions to the utilization of commuter rail by handicapped persons which, when adopted, will be of major assistance in their integration into the urban workforce.

Access to passenger trains has been the subject of Canadian research. A number of lift devices have been built, and are now in use at VIA stations, by means of which a wheelchair passenger can reasonably rapidly board or exit from the train. An onboard lift has also been studied and is in the final stages of prototype design.

Modal Interfaces

As has been previously mentioned, the provision of an access vehicle is of limited value if difficulty is encountered in actually gaining access to the vehicle, rather than onto it. This problem is particularly acute in the large transportation terminals which were built with little or no consideration for those travellers who are not fully mobile. Long distances and level changes are major impediments to the handicapped traveller.

One exciting Canadian development with applications in transportation terminals is the Small Carrier for Alternative Transportation (SCAT). The device is a modular transfer vehicle developed for both indoor and outdoor use in terminals and other sites such as pedestrian malls and public concourses. The vehicle consists of a motorized platform to which can be added one or more non-motorized modules. The vehicle is accessible by a ramp and thus may be used to transport wheelchair passengers, reducing the work of attendants.

A major research report was recently prepared for Transport Canada on the topic of stairway lifts for use in transportation terminals. This type of lift is currently in use in three airports, a ferry terminal and a railway station. Research on these devices has determined that they do indeed facilitate transportation for handicapped persons but they also suffer from certain drawbacks. Inclined stairway lifts are generally slow and have specific ergonomic shortcomings. Where possible an elevator is a preferable option to stairway lifts.

Conclusions

Considerable research, both in Canada and elsewhere, has been undertaken in recent years on transport for the physically handicapped. All the 'easily strengthened links' in the chain of accessibility have been repaired. It has now been realized that all this effort is of limited value if the other links in the chain are not also strengthened. Effort is now underway in this area.

We are still a considerable distance from attaining a fully accessible continuum. Fully accessible trains are not available, many air terminals are difficult to traverse and bus travel is fraught with problems for the handicapped traveller. Efforts are being made, however, in all these areas.

Future research, while not neglecting to attempt to fill all the gaps in the current travel sequences, should concentrate in one particular area. To date the amount of research undertaken on accessibility and use of automobiles by the handicapped has been in no way proportional to the potential benefits of this mode. As previously indicated, the personal automobile has greater flexibility than any other mode. The automobile frees the traveller from schedules while, at the same time, giving the driver the opportunity to express self sufficiency. While it is acknowledged that transit and commuter rail are important, the availability of suitable vehicles for operation by the handicapped would increase their transportation freedom more than any other development. Futher efforts must be made to integreate the physically handicapped into society by this means.

THE BRITISH COMMUNITY BUS CONCEPT -
LESSONS FROM THE SOAR VALLEY EXPERIMENT

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Introduction and Background

The first community bus project began operation in Norfolk in November 1975. By mid - 1978 sixteen community bus projects were operating in several counties in England and Wales, and this had risen to more than 50 in 1984. The community bus has become a popular form of rural transport innovation, with many counties who have yet to sponsor an experiment, actively considering doing so.

The purpose of this paper is to review the role of community buses in rural areas and examine the reasons for their success, using case-study material collected in Nottinghamshire by the CTSRU in the period 1978 to 1984.

The concept of the community bus comprises a partnership between the sponsoring agency (normally the County Council or the National Bus Company) and the local community to be served by the project, and includes the following arrangements:

the sponsoring agency	- provides the vehicle (usually a minibus, 12 - 17 seats; or a midibus, 17 - 35 seats), administration and operating costs up to a pre-determined level, and gives technical and professional advice, including monitoring of the project.
the local community	- manages the day-to-day operations on a voluntary basis, including taking bookings and arranging schedules, collecting fares, keeping records, and the recruitment of voluntary drivers.

Because the projects are organised, in the main, on a voluntary basis, they provide a low cost solution to the problems of rural areas where little or no conventional public transport exists. In addition, because they are managed by a local operating group of community representatives, they can respond to the transport needs of the local population in a way which conventional bus services would find difficult: an example of this is the provision of services which cut-across established 'services boundaries', such as providing special services for schools and social service agencies alongside their scheduled operations. In this and other ways they can therefore become the focus of transport co-ordination and service integration (1, 2).

The policy towards community buses has been helped by recent changes in transport regulations, which collectively allow non-profit making projects to operate without meeting the normal Public Service Vehicle regulations, and by-pass the need to gain a Bus Operator's Licence. Relaxation of these regulations is contained in the 1977 Minibus Act (3), the 1978 Transport Act (4) and the 1981 Public Passenger Vehciles Act (5). A recent Government White Paper on the bus licensing system (6) has proposed further de-regulation of conventional bus services with the objective of increasing competition for bus routes; however it seems unlikely that this move will have any direct effect on the sponsorship of community bus projects.

Responsibility for public transport planning in rural areas rests with the Shire County Councils (like Nottinghamshire) in England and Wales (Regional Councils in Scotland), who have a duty to:

(i) "develop policies to promote the provision of a coordinated and efficient public transport system to meet the county's need";

(ii) "take steps to promote coordination, amalgamation and reorganisation of road passenger transport undertakings in the county", including special transport services;

(iii) prepare and publish by 31 March each year an annual Public Transport Plan for the following 5 year period. This should contain a review of the passenger transport needs of the county; a statement of the County Council's policies and objectives; an estimate of the money required to achieve these; details of consultations carried out; financial arrangements made with operators; and details of concessionary fare schemes for elderly and disabled people.

The preparation of Public Transport Plans including special or unconventional services has encouraged the counties to experiment with unconventional services, and community buses have emerged as a popular option in isolated rural areas.

Support for the experimentation with community buses has come from the Department of Transport, who have themselves sponsored a project in Devon as part of their Rural Transport Experiments programme (RUTEX) (7), and also published a guide for community transport operators (8); from a Select Committee of Members of Parliament (9); and from an independent study undertaken by the National Consumer Council in 1978 (10). A summary of the operating characteristics of 16 projects is provided in table 1 (overleaf).

Number of Schemes	16
Average population of villages served (excluding destinations)	1600
Number of mini / midi buses used in each project	1
Number of days operated each week a) scheduled services b) special services	 4 6
Average number of single passenger journeys on scheduled stage services per week	120
Average weekly revenue a) scheduled services b) special services c) total	 £15.37 £ 8.52 £23.89
Average weekly cost of operation a) vehicle operating costs b) administration costs c) total	 £28.79 £ 8.28 £37.07
Average weekly operating subsidy	£13.18
Average vehicle miles per week	213
Average weekly cost per passenger journey	£0.30
Average weekly subsidy per passenger journey	£0.11

Table 1 - Summary Estimates of Operating Statistics of 16 Community Buses in 1978 (at 1978 prices) (9, 10)

Community Buses in Nottinghamshire

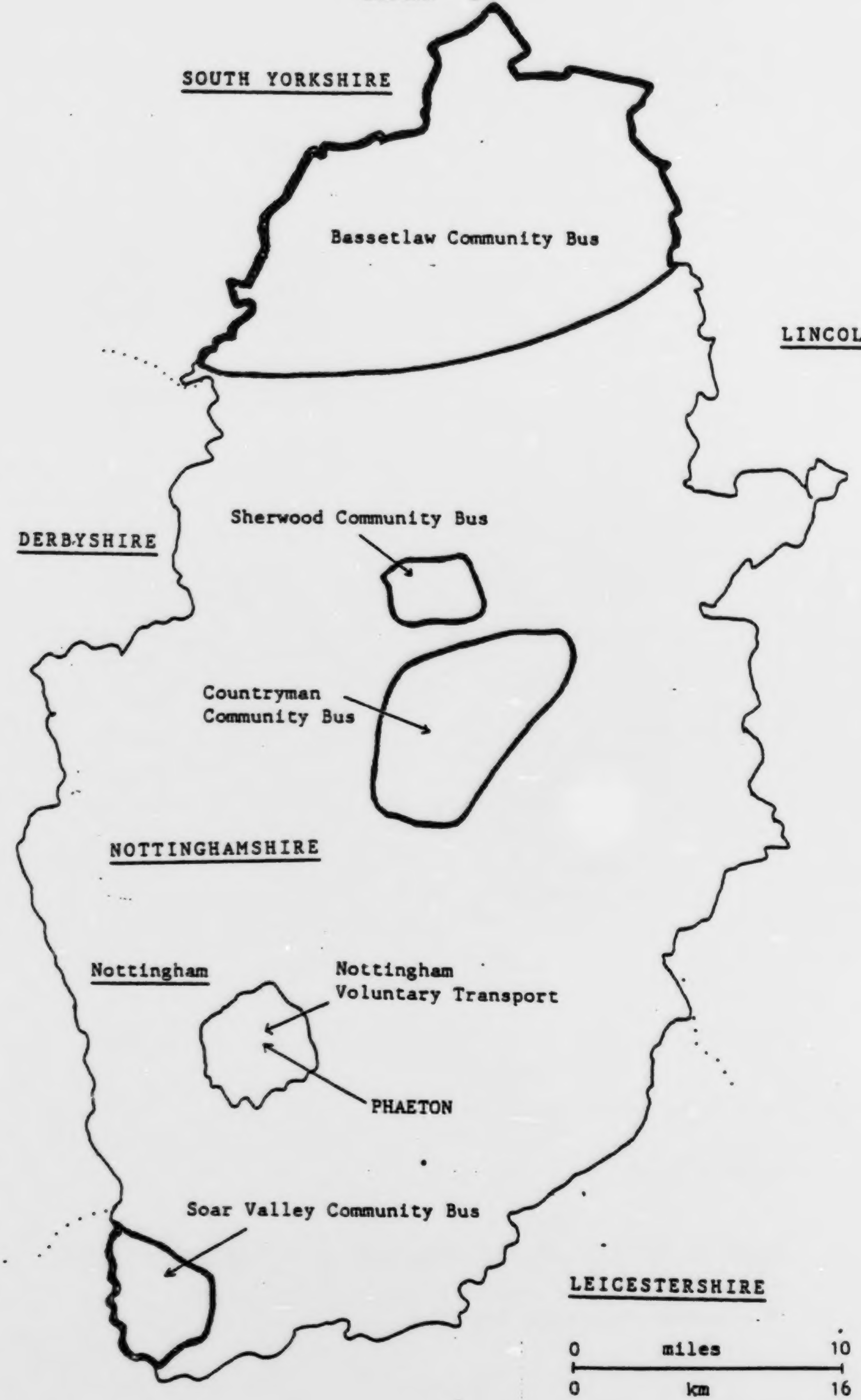
There are currently three rural community bus schemes in Nottinghamshire sponsored by the County Council, and three other special services worth mentioning which are sponsored by independent voluntary organisations (see Map 1).

The voluntary sector projects do not provide scheduled services but operate on a 'group hire model' to other non-profit making groups and provide a range of transport services to handicapped and elderly people to attend health and social services centres. This community transport role was augmented in 1981 by the provision of a Dial-a-Ride service for the disabled - P.H.A.E.T.O.N.- using two specially equipped vehicles. Descriptions of these voluntary sector schemes have been provided elsewhere (11, 12).

Nottinghamshire was one of the first counties to experiment with community buses, beginning in 1978 with the Bassetlaw Community Bus, and has subsequently accumulated six years operating experience. Simultaneously, the local communities served by the projects have learnt to 'fine-tune' the services to their needs and the resultant symbiosis between the community and the bus services has become an important factor for consideration when the Council undertakes its annual evaluation of the projects. A summary review and evaluation of the Bassetlaw and Countryman community bus projects is provided below: the Soar Valley project will be considered in more detail later.

1. The Bassetlaw Community Bus was the first such experiment in the UK to operate after the 1978 Transport Act relaxed the licensing regulations. Whilst the project conforms to the partnership principles and dual purposes of other projects, in three specific areas it is unique. Firstly, the area of operation is large (250 sq km) and includes 34 settlements with a total population of 12,000. Secondly, whilst the project is managed by a local voluntary committee, the bus is owned and operated by a local bus company on an annual contract (the County Council providing the revenue support), and is not therefore driven by volunteers. Thirdly, the midi-bus sized vehicle (20 seats) is equipped with a tail-lift for wheelchair passengers.

The size of the area to be covered and the special design of the vehicle to be used persuaded the County Council to fund a professionally driven service as a special experiment, outside of its normal revenue support payments to scheduled bus operators. The project was suggested following a study undertaken by the County Council's Planning and Transportation Department into accessibility to rural services in Bassetlaw (13). This study identified particular problems of gaining access to health facilities and social services centres, alongside more general problems of access to shopping and leisure facilities. These problems were especially important to elderly and disabled people and the requirement was therefore to operate a special bus with a tail-lift.


SOUTH YORKSHIRE
Bassetlaw Community Bus
LINCOLNSHIRE
DERBYSHIRE
Sherwood Community Bus
Countryman Community Bus
NOTTINGHAMSHIRE
Nottingham
Nottingham Voluntary Transport
PHAETON
Soar Valley Community Bus
LEICESTERSHIRE
0 miles 10
0 km 16

Map 1 - The Location of Nottinghamshire's Community Transport Projects

A summary of the operating characteristics and performance is provided in Table 2 below.

	1983/84	1982/83
One-way passenger trips by services:-		
school	3,712	4,304
shopping	14,000	10,263
health and welfare	3,496	3,575
leisure	2,058	1,208
private hire	560	310
total	23,853	19,660
Costs (£):-		
Basic Contract		
- drivers hours *	11,792	11,203
- mileage **	6,788	7,114
administration	1,440	1,375
private hire	315	245
total	20,335	19,937
Revenues (£):-		
Bassetlaw School Contract	6,337	7,080
concessionary fares (elderly and handicapped)	513	600
on-bus fares	1,213	705
off-bus fares	1,445	1,250
private hire	377	250
total	9,885	9,885
Net Deficit (£)	10,450	10,052
Subsidy per passenger journey	43.8 pence	51 pence

* 49.3 hours/week
** 29905 miles

Table 2 - Operating Performance of the Bassetlaw Community Bus

(Source: Environment Committee Report, 14 March 1984, Nottinghamshire County Council)

The size of the net deficit and the comparatively high level of subsidy per passenger has threatened on more than one occasion in the six years of its operation to reduce the number of services operated, but on the credit side the use of the bus has reduced the expenditure on school contracts and social services work though this is not recorded in the internal audit of operations. Perhaps most persuasively of all, however, is the wide support for the service from the local community and politicians, and the recognition that in overall terms the project is judged a success and could not be provided any cheaper by other means. Finally, in March 1984, the County Council re-affirmed their support to the project by approving £5,000 towards the cost of a replacement vehicle.

2. The Countryman Community Bus Service. Unlike the Bassetlaw project, the Countryman project corresponds more closely to the ideal community bus model. The area of operation extends over ten small settlements with a combined population of 1,500; the vehicle is managed and operated by volunteers; and the vehicle used is a 12 seat minibus. The service operating statistics and performance are summarised in Table 3.

	1982/83
One-way passenger trips:-	
shopping and personal business	1,633
school	3,500
leisure	183
total	5,316
	£
Costs:-	
fuel	440
maintenance	254
insurance/tax	295
Parish Operating Group expenses	82
other (publicity etc)	20
total	1,091
Revenues:-	
on-bus fares	580
Scholars Season Tickets	345
private hire	285
concessionary fares (elderly and handicapped)	360
total	1,570
Net Operating Profit	479

Table 3 - Operating Performance of the Countryman Community Bus

(Source: Environment Committee Report, 22 February 1984, Nottinghamshire County Council)

In 1983/84 the project is expected to make another operating profit, of £400. This excludes the vehicle depreciation and replacement cost, which if included in the audit would result in a net annual cost of the scheme of £1,760, equivalent to a 33 pence subsidy per passenger journey.

Both these projects are considered to be succesful and continue to receive financial support, and as intimated previously their success is judged on social criteria as much as financial performance. In order to investigate the social impact of community bus projects on local comunities it was decided to investigate one project, the Soar Valley Community Bus, in detail. The results of this case-study are presented below.

The Soar Valley Community Bus

The project began in September 1979 and has since been closely monitored by the County Council and the CTSRU, who collaborated in a travel survey of the area in October 1979. The project is organised in a similar way to the Countryman project (which it preceded), with a Parish Operating Group controlling the day-to-day management and organising voluntary drivers.

The settlement geography of the area is illustrated in Map 2, showing the spatial distribution of population and activities and the route of an existing scheduled bus service. The major transport problem in the area arises from the absence of a public transport link from the Soar Valley to East Leake and West Bridgford where many activities are located, including the secondary school, health centres, sports centre and Council offices. In addition, the project aimed to provide a limited scheduled service into Loughborough, the local market town situated in north Leicestershire, for three of the settlements which have no scheduled bus services.

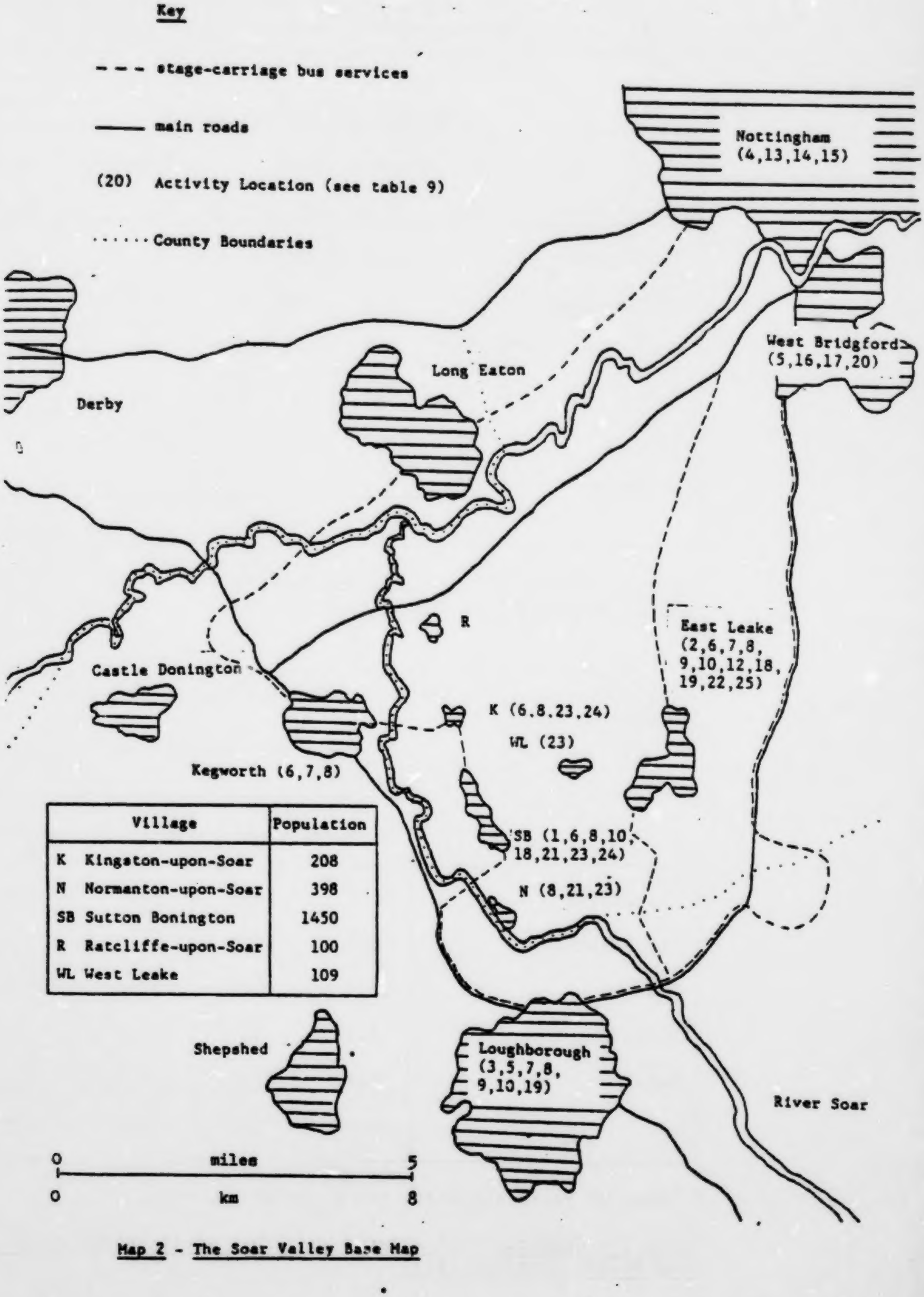
In monitoring the project the following exercises were conducted:-

(i) a travel questionnaire survey of 2,265 people in 789 households (94% of the households in the area)

(ii) an analysis of patronage on the existing bus service, by destination, journey purpose and frequency.

(iii) an accessibility analysis using the data collected and incorporating a time-geographic approach.

(i) The household questionnaire survey revealed high household car ownership rates averaging 81.2%. In addition 30% of the households owned two or more cars. However, a breakdown of driving licence ownership reveals that whilst male driving licence ownership is near the car ownership level (at 80%), only 51.7% of adult females own a driving licence. The implication of this being that many women must rely on other forms of transport other than a car for their mobility, especially when the family's only car is not available. The survey also identified 113 handicapped people (5%) who could not use the car or local bus service unaided. Amongst


Key
- - - stage-carriage bus services
——— main roads
(20) Activity Location (see table 9)
······ County Boundaries
Nottingham (4,13,14,15)
West Bridgford (5,16,17,20)
Long Eaton
Derby
R
East Leake (2,6,7,8, 9,10,12,18, 19,22,25)
Castle Donington
K (6,8,23,24)
WL (23)
Kegworth (6,7,8)
SB (1,6,8,10, 18,21,23,24)
N (8,21,23)
Shepshed
Loughborough (3,5,7,8, 9,10,19)
River Soar
0 miles 5
0 km 8

Village	Population
K Kingston-upon-Soar	208
N Normanton-upon-Soar	398
SB Sutton Bonington	1450
R Ratcliffe-upon-Soar	100
WL West Leake	109

Map 2 - The Soar Valley Base Map

the 245 elderly people, driving licence ownership is similar to that of women.

An analysis of local trip patterns demonstrates the dominance of the car mode amongst non-elderly adults, but also shows that a significant number of people rely on the bus mode (Table 4).

Average Weekly Frequency

	All Journeys		Work		Shopping		Leisure	
Travel Mode	Nos.	%	No.	%	No.	%	No.	%
Car Driver	777	54.5	263	60.1	303	50.5	211	54.0
Car Passenger	195	13.7	20	4.5	92	15.3	83	21.2
Bus	219	15.3	36	8.2	130	21.6	53	13.5
Walk	107	7.5	40	9.1	46	7.6	21	5.3
Bicycle	92	6.4	52	11.8	25	4.1	15	3.8
Motorbike	33	2.3	23	5.2	3	0.5	7	1.7
	1423	100	434	100	600	100	390	100

Table 4 - Travel mode and journey purpose amongst non-elderly adult Soar Valley residents (October 1979)

Of particular interest are the travel modes of elderly people, which are compared to those of other adults for shopping and leisure journeys in Table 5.

	Shopping		Leisure	
	*Elderly %	Other Adults %	*Elderly %	Other Adults %
Car Driver	43.7	50.5	52.7	54.0
Car Passenger	8.3	15.3	13.8	21.2
Bus	38.5	21.6	25.0	13.5
Bicycle	3.1	4.1	5.5	-
Walk	6.2	7.6	2.7	5.3
	100	100	100	100

* Women 60 years and over. Men 65 years and over.

Table 5 - Comparison of elderly and other adult travel modes in the Soar Valley (October 1979)

Whilst the car is still the most popular mode (reflecting the increasing car-ownership rates among the elderly), the bus mode is especially important amongst the elderly for shopping and leisure activities.

The survey also collected information on secondary school-children's (11 - 18 year olds) travel patterns for non-school activities which also reveals their dependence upon the family car for mobility, followed by the bus mode (Table 6).

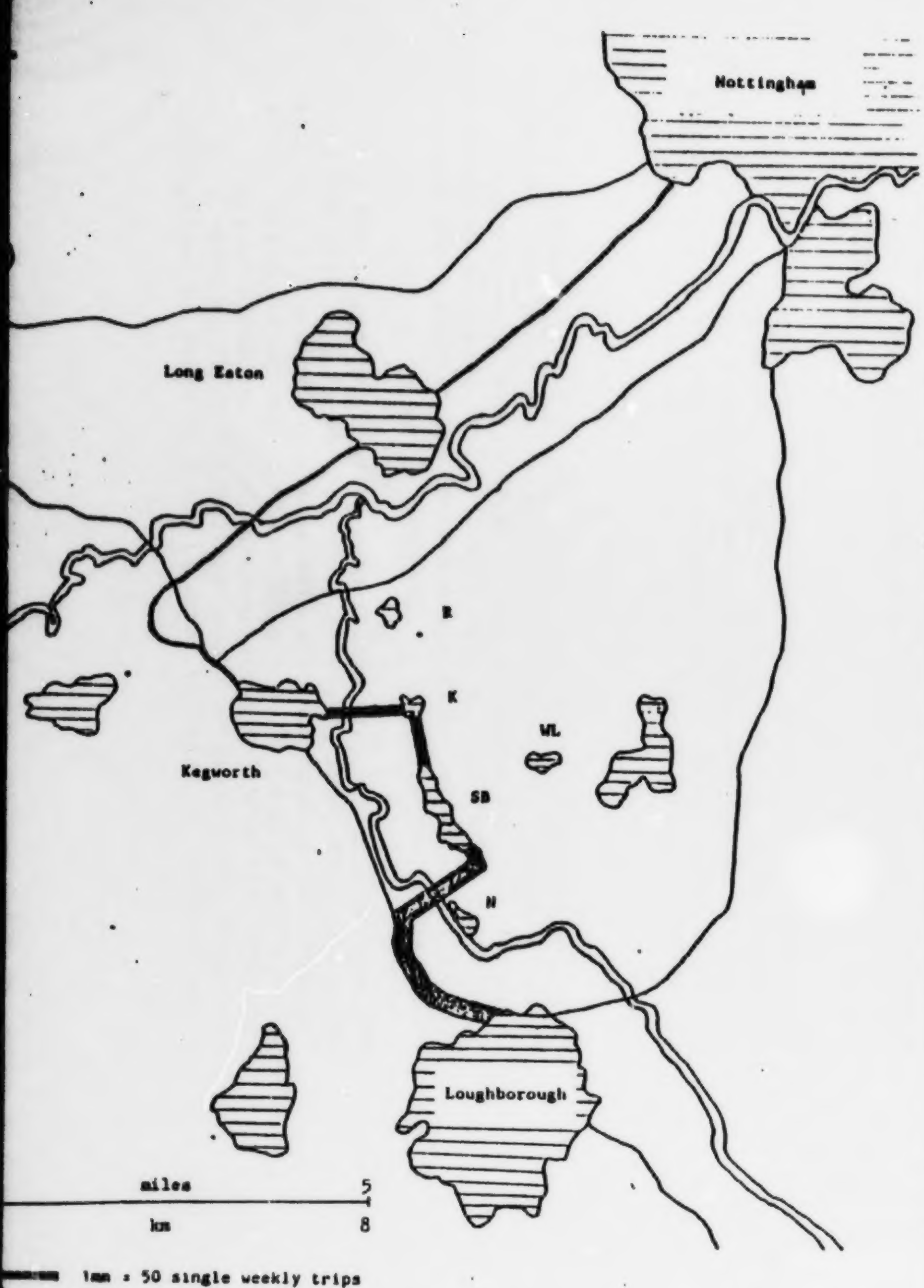
	Non-school Journeys	
	Nos.	%
Car Driver	9	6.0
Car Passenger	83	56.0
Bus	27	18.2
Bicycle	26	17.5
Walk	3	2.0
Total	148	100

Table 6 - School children's travel modes in the Soar Valley area (October 1979)

Taken together the survey revealed a significant dependence on bus services even in an area of high household car ownership: in particular, amongst the elderly, women who cannot drive and school children. These groups in the community must rely on both the family car and the availability of a driver and on the local bus service.

(ii) The analysis of the local scheduled bus service was undertaken to plot the destinations of bus passengers, and these are illustrated in Map 3a. The corresponding travel destinations of car users is illustrated in Map 3b. The maps show trip frequencies by destination, utilising data collected from a survey of bus patronage and from the household survey.

The maps show clearly the differences between car travel and bus travel, both in terms of the frequency of use of each mode and by destination. Assuming that the free choice of destination available to car users is desired in a similar way by bus users, the analysis highlights the restricted destination choice available to bus passengers and identifies those destinations to which there is an access problem. Principally, this is the East Leake to Nottingham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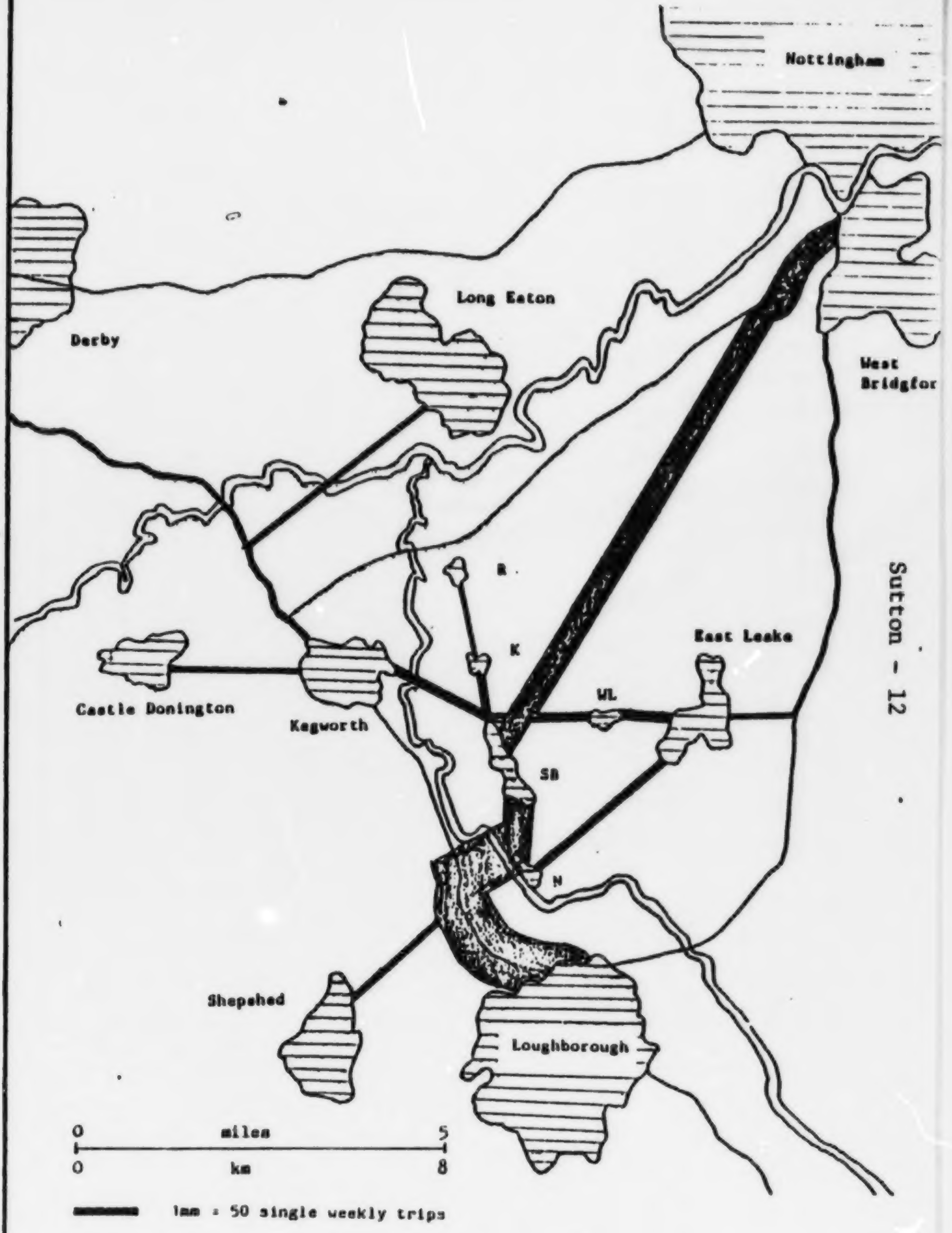
SB
N
Loughborough
miles
5
km
8
1mm = 50 single weekly trips

Map 3(a) - Scheduled Bus Patronage Volume by Destination (October 1979)

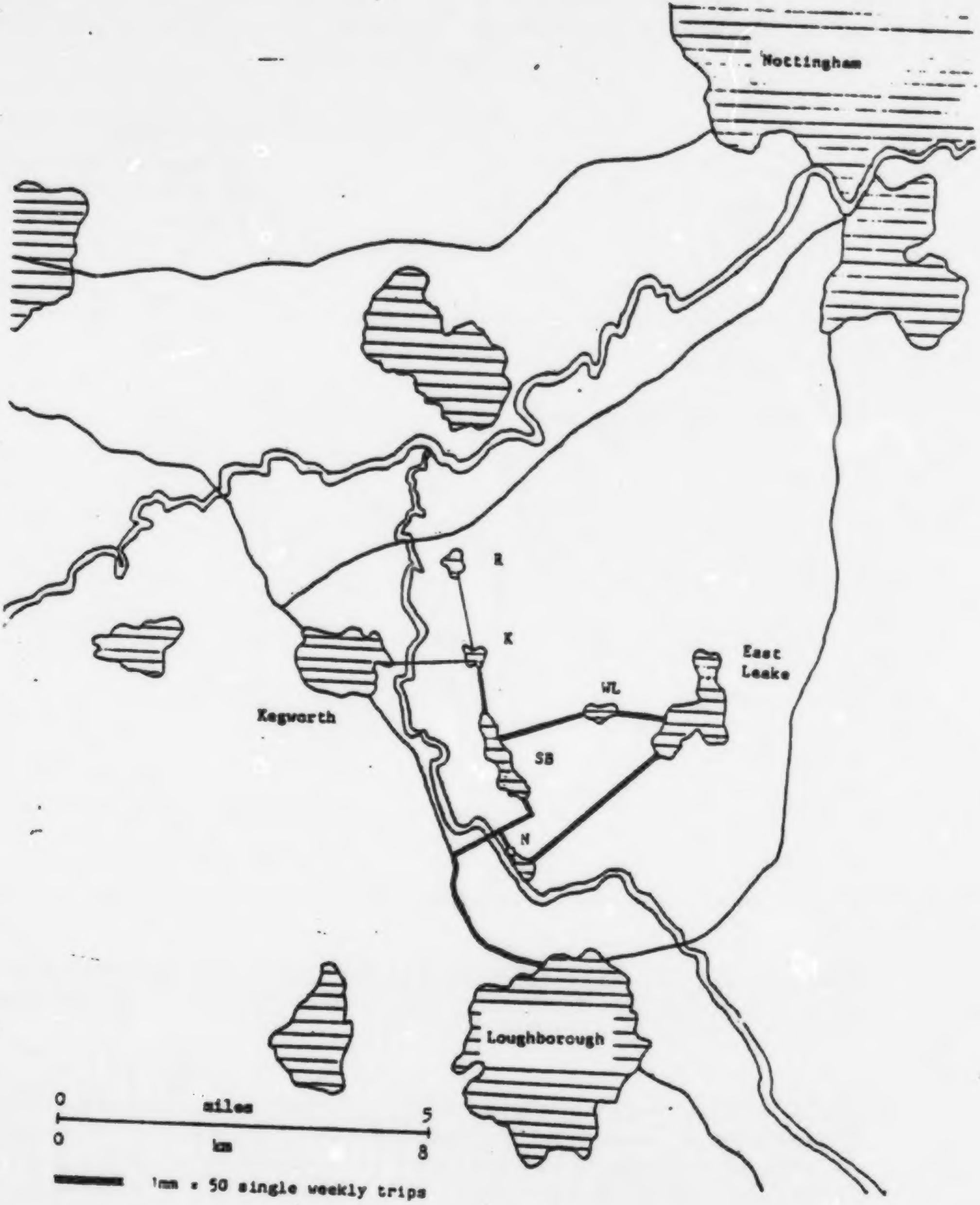

Nottingham
Derby
Long Eaton
West Bridgfor
R
K
East Leake
WL
Castle Donington
Kegworth
SB
N
Shepshed
Loughborough
0
miles
5
0
km
8
1mm = 50 single weekly trips

Map 3(b) - Single Weekly Car-trips by Volume and Destination (October 1979) corridor via West Bridgford and to a lesser extent access from 3 of the settlements to Loughborough. The household survey asked questions on travel problems and calculated a latent demand for bus travel of 265 single weekly bus journeys per week, distributed by destination in Table 7.

	Latent Demand		Soar Valley Community Bus actual weekly patronage (Sept. 1979 to June 1980)
	No.	%	No.
Destination			
Within Soar Valley area	3	1.0	43
Kegworth	9	3.1	7
East Leake	46	17.7	41
Long Eaton	9	3.1	
Loughborough	93	35.4	37
Nottingham	68	26.0	
Derby	5	2.0	
Other	32	11.4	
Totals	265	100	128

Table 7 - Latent demand for public transport by destination (October 1979) and actual patronage (September 1979 to June 1980) (single weekly bus journeys)

Table 7 also compares the actual performance of the community bus in satisfying latent travel demands. The figures only show patronage by community bus destination, and some of those travelling to East Leake, for example, will be able to connect with a scheduled bus service to West Bridgford and Nottingham (Map 3c). This analysis indicates the spatial performance of the project, and especially in providing a means of accessibility to East Leake, and of enhanced mobility within the Soar Valley area. By June 1980 the Soar Valley community bus was responsible for a 48% increase in bus patronage by residents in the area, over and above the existing scheduled service. This statistic demonstrates the trip generation qualities of the project, and the correctness of the decision to improve accessibility to the East Leake to Nottingham corridor.


Nottingham
R
K
East Leake
WL
Kegworth
SB
N
Loughborough
0
miles
5
0
km
8
1mm = 50 single weekly trips

Map 3(c) - Community Bus Patronage by Volume and Destination
Average Single Weekly Journeys (September 1979 - June 1980)

(iii) The accessibility analysis. The purpose of the accessibility analysis was to indicate those activities which were inaccessible, before and after the introduction of the community bus and, using the survey data, to estimate the proportion of the local population who are 'mobility deprived'.

The method of undertaking an accessibility analysis is relatively straightforward and involves the following exercises:

1. Specifying the activities to be included and their spatial location (Map 2).
2. Defining accessibility standards for each activity in terms of frequency of access, length of stay and maximum journey times acceptable in order to reach an activity (Table 8).
3. Defining maximum walking times from home to the nearest bus stop (½ mile or 10 minutes) and between the journey destination and the nearest bus stop.
4. If the activity cannot be reached or take place within the defined standards the access score is zero. If the activity is possible it scores one (Table 9).
5. For each activity which is inaccessible, estimates of the number of people affected are computed from the household survey data base (Table 10).

The methodology was originally designed and tested in an accessibility study conducted by Moseley et al in 1977 (14) and has since been incorporated into several transport studies (15 - 18). The normative establishment of minimum standards of service has been criticised for being 'unscientific' but the simplicity of using the technique, once the necessary information has been collected, has benefits for examining alternative courses of action within the policy-making process. In this case-study, empirically collected data is used within the accessibility analysis, which enhances both the validity and relevance of the technique.

The time-geographic approach to accessibility used in this study, as originally formulated by Hagerstrand (19, 20), is particularly suited to examining the potential of small scale experiments like the community bus projects. Using dimensions of time and space, the analysis produces 'time-space prisms' within which accessibility is possible. Figure 1 illustrates the 'time-space prisms' within which travel by stage-carriage bus and the community bus is possible. Increasing the area of accessibility can be achieved by extending the schedules of current services, extending the choice of destination or a combination of both.

The selection of the activities and minimum standards of access are derived from Moseley's criteria for rural areas and modified according to local policy in Nottinghamshire (as defined in the County's Public Transport Plan, 1979-1984 (21)). Altogether 22 activities were selected (Table 8) and minimum standards of access, within defined time-scales, were specified. The activities selected include: access to 4 employment locations; access to 9 shopping

Activity	Minimum Frequency (days per week)	Maximum Journey Time (minutes)	Minimum length of stay possible (hours)
1. Employment	5	60	8
2. Supermarket	6	30	2
3. General Store	6	20	1
4. Chemist	6	30	1
5. Post Office	1	30	1
6. Bank	1	30	1
7. General Doctor	5	30	2
8. Dentist	5	30	2
9. Health Centre	5	30	2
10. Hospital	7	60	2
11. Job Centre (Govt. Employment Office)	1	30	3
12. Social Security Office	1	30	3
13. District Council Office	1	30	2
14. County Council Office	5	30	2
15. Library	5	30	2
16. Evening Classes	5	30	2
17. Technical College	5	30	8
18. Primary School	5	30	7
19. Secondary School	5	30	7
20. Public House	2	30	2
21. Community Centre	1	30	3
22. Sports Centre	1	30	2

Table 8 - The Accessibility Standards

Activity	Sutton Bonnington		Normanton-upon-Soar		Kingston-upon-Soar		West Leake		Ratcliffe-upon-Soar	
	SC	SVCB	SC	SVCB	SC	SVCB	SC	SVCB	SC	SVCB
1. Employment within Soar Valley	1		1		1		0	1	1	
2. Employment East Leake	0	1	0		0		0	1	0	
3. Employment Loughborough	1		1		1		0		1	
4. Employment Nottingham	0		0		0		0		0	
5. Supermarket	1		0	1	1		0	1	1	
6. General Store	1		1		1		1		1	
7. Chemist	1		0	1	1		0	1	0	
8. Post Office	1		1		1		1		1	
9. Bank	1		1		1		0	1	1	
10. General Doctor	1		1		1		0	1	0	
11. Dentist	1		0	1	1		0	1	0	
12. Health Centre	0	1	0	1	0		0	1	0	
13. Hospital	1		0		1		0		0	
14. Job Centre	0		0		0		0		0	
15. Social Security	0		0		0		0		0	
16. District Council	0	1	0	1	0		0	1	0	1
17. County Council	0	1	0	1	0		0	1	0	1
18. Library	1		1		1		0	1	1	
19. Evening Classes	0		0		0		0		0	
20. Technical College	0		0		0		0		0	
21. Primary School	1		1		1		0		0	
22. Secondary School	0	1	0	1	0		0	1	0	
23. Public House	1		1		1		1		1	
24. Community Centre	1		0		1		0		1	
25. Sports Centre	0	1	0	1	0	1	0	1	0	1
Accessibility Score Change (maximum possible score = 25)	14 → 20		9 → 17		14 → 15		3 → 16		9 → 12	

Key

1 = accessible
0 = inaccessible

SC = existing stage-carriage bus service
SVCB = Soar Valley Community Bus

Table 9 - The Accessibility Scores for the Five Settlements - Impact of the Community Bus

Activity	Before(%)	After(%)	Change(%)
1. Employment within Soar Valley	2.5	2.5	0
2. Employment East Leake	3.2	1.8	- 1.4
3. Employment Loughborough	5.3	1.8	- 3.5
4. Employment Nottingham	29.1	29.1	0
5. Supermarket	9.3	-	- 9.3
6. General Store	-	-	0
7. Chemist	11.0	2.7	- 8.3
8. Post Office	-	-	0
9. Bank	2.0	-	- 2.0
10. General Doctor	4.2	4.2	0
11. Dentist	2.1	2.1	0
12. Health Centre	13.0	2.4	-10.6
13. Hospital	4.8	4.8	0
14. Job Centre	2.8	2.8	0
15. Social Security	2.8	2.8	0
16. District Council	18.8	1.8	-17.0
17. County Council	18.8	1.8	-17.0
18. Library	4.4	-	- 4.0
19. Evening Classes	18.8	18.8	0
20. Technical College	18.8	18.8	0
21. Primary School	19.7	19.7	0
22. Secondary School	26.3	4.8	-21.5
23. Public House	-	-	0
24. Community Centre	4.4	4.4	0
25. Sports Centre	18.8	-	-18.8

Table 10 - The Percentage Affected by Mobility Deprivation before and after the Community Bus

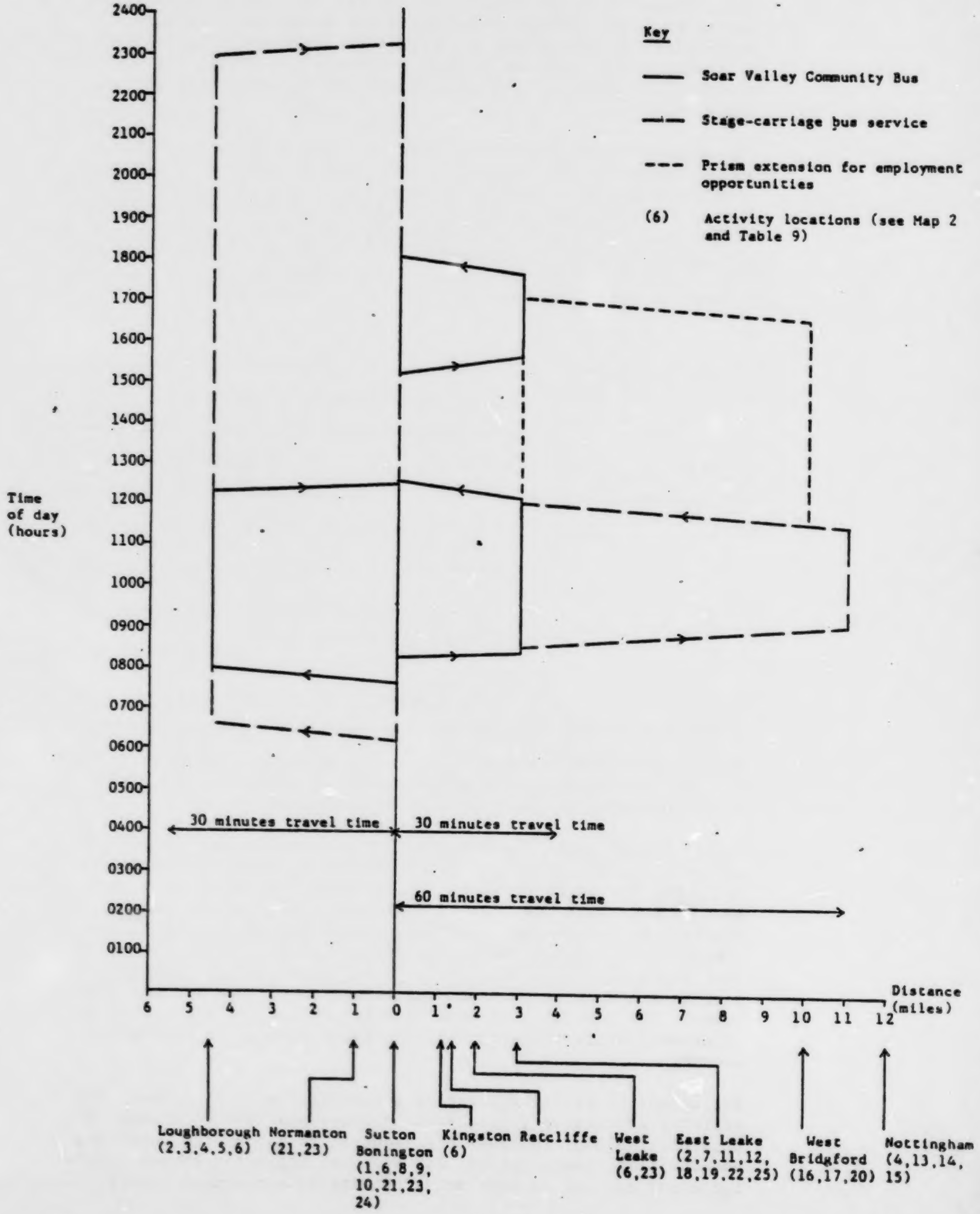


FIGURE 1 Time-Space Accessibility Prisms

and personal business activities; access to 4 health activities; access to 5 educational activities; and access to 3 leisure activities. Not all these activities are relevant to all the different social and age groups, and hence the reason for computing the numbers deprived of adequate mobility for each activity in Table 10.

The accessibility score calculated in Table 9 illustrates those activities which are accessible from each settlement in the project area. the computed scores also show the impact of the community bus in improving access: in four settlements there has been a significant improvement (the exception being Kingston-upon-Soar), with particularly noticeable benefits to residents in West Leake and Normanton-upon-Soar. In rank order, the accessibility potential of each settlement, before and after the community bus, is as follows:

Rank	Access Score (maximum = 25)	
	Before the community bus	After the community bus
1	14(Sutton Bonington) (and)	20 Sutton Bonington
2	(Kingston-upon-Soar)	17 Normanton-upon-Soar
3	9(Normanton-upon-Soar (Ratcliffe-upon-Soar	16 West Leake
4		15 Kingston-upon-Soar
5	3 West Leake	12 Ratcliffe-upon-Soar

Despite these improvements many of the activities remain inaccessible and the next stage in the analysis was to calculate the number of people affected by their continuing isolation.

Table 10 summarises the results of this exercise and identifies those activities for which there has been a considerable improvement and those for which problems still remain. For example, significant improvements have been gained in accessibility to the supermarket, chemist, health centre, the District and County Council offices, the secondary school and to the sports centre: whilst the major inaccessibility problems remain to employment activities in Nottingham, evening classes, the technical college and the primary school. The results also show that for most other activities only a relatively small proportion of the local population are denied access.

The advantage of disaggregating accessibility by settlement and activity in this way, is that it becomes possible to examine the possible range of improvements required to reduce the remaining accessibility inequalities. For example, improving access to the technical college in West Bridgford and to employment opportunities in Nottingham, could be achieved by extending the existing community bus service to East Leake eastwards, to connect with the main Loughborough to Nottingham bus services. Conversely, the problem of access to the primary school and to evening classes is not one of destination but of the scheduling of services, that is, temporal rather than spatial. Another area of concern is access to the doctor, health centre and hospital, especially for the elderly, even though the numbers may be small. The solution for such a small number may be to organise a voluntary car scheme for health journeys.

In this way, the analysis helps us to identify a primary bus network of stage-carriage bus services, a secondary community bus network and a possible tertiary network of voluntary car services, with each level in the hierarchy providing access possibilities defined by dimensions of destination and time.

The evaluation of the Soar Valley community bus has demonstrated its impact in improving accessibility and mobility choice to non-car users in the area. The resultant improvements are especially beneficial to elderly people in respect of journeys for shopping and personal business (an example of this is a special service operated on one afternoon each week to a hypermarket on the southern periphery of Nottingham). Statistics collected for the first quarter of 1984 reveal that, on average, 346 passengers are carried each week on scheduled services, including 53 elderly people (15.3%); this compares with 128 per week in its first 9 months of operation in 1979-1980. The success of the project in attracting passengers to both scheduled and special services has resulted in only a 12 pence subsidy per passenger, the lowest of the three projects when all costs are considered.

The project is also judged a success by the local community who have supported the scheme enthusiastically from the beginning. The social benefits of the project, apart from the measured reductions in mobility deprivation, are associated with the increasing social interaction between villagers, as evidenced by an increase in organised social activities which rely upon the community bus (eg. elderly persons outings) and the more regular social contacts between people in adjacent villages (approximately 33% of the community bus journeys are undertaken totally within the Soar Valley area). These social effects should not be underestimated, because they support directly the revenues collected and indirectly promote awareness and a local sense of pride in the project. Similar sentiments are also expressed by residents in the other two project areas.

Conclusion and Recommendations

The success of the Soar Valley project has been sufficiently encouraging to persuade the County Council to examine other areas where a community bus would be successful - the Countryman project is one example. However, to date, only rural areas have been considered, primarily because the community bus concept is regarded as a low cost alternative to more costly conventional services in areas where demand is low. The experience in Nottinghamshire suggests that the community bus model is sufficiently robust and flexible to operate in a number of different environments meeting a wide range of needs, as the contrast with the Bassetlaw and Countryman projects demonstrate. It is worthwhile considering the role of community buses not as cheap substitutes for conventional services but as valuable additions to the local pasenger transport hierarchy, meeting a range of needs which conventional services are unable or unwilling to provide: examples of this are the hire of the vehicle to a local group, or the provision of special shopping services to elderly or handicapped people. The successful implementation of the project is also critically dependent upon the support and commitment of the local community and the abilities of the volunteer organisers.

In accessibility terms the community bus is most successful in meeting 'secondary needs', for shopping and personal business journeys, and appears too limited in scope to cater for regular employment activities. The analysis of the Soar Valley project has demonstrated the impact of the community bus in a relatively small area, with measurable improvements in the level of mobility choice available to local residents and reductions in the level of mobility deprivation. These quantitative factors, together with the flexible use of the services in meeting locally expressed needs, presents a persuasive argument for experimenting with the model in urban areas, both suburban and inner city, where in the case of the latter special needs groups are often concentrated and where levels of car ownership, and more importantly of car use, are low. If, as hypothesised here, the community bus fills a niche in the passenger transport hierarchy to good effect in rural areas, there is no reason to suppose it would be no less successful in urban environments. In fact, we contend, one could reasonably assume they would be more successful.

Current policy is to restrict community bus projects to rural areas, and current licensing restrictions would make it difficult to conduct an exact replica of the Soar Valley or Countryman projects in a town or city. Nevertheless, the possibility remains, and at the very least the community bus projects have demonstrated the success of combining scheduled and private hire services from a community base. This lesson, we believe, will be of immense value to transport planners in the future.

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TRAINING THE TRANSPORTATION HANDICAPPED TO USE PUBLIC TRANSIT

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TRAINING FOR THE TRANSPORTATION HANDICAPPED TO USE PUBLIC TRANSIT

by

CATHLEEN E. TOWNER

INTRODUCTION

It has been assumed that for most people with disabilities public transit is not a viable solution to travel. Their disabilities prevent them from having the skills needed to plot a route, read transit directions,identify landmarks, manuver crowds, and generally travel as a member of the general public. Lift-equipped buses or para-transit seemed the only feasible, if very expensive, solutions to making transit accessible thus meeting the mandates of Section 504. Actually those with many vastly different types of disabilities are prevented from meeting their travel needs not because of their disability but because they have not been expected or taught how to travel. This paper will examine mobility training as a means of making public transit accessible to thousands of those with disabilities. It will discuss the unique approach to mobility training developed in Rochester, New York. Lastly, it will present some ideas for expanding scarce transportation resources through generic mobility training.

Throughout the 70's it was thought that those with physical disabilities were the only individuals unable to use public transit. The need for independent travel by those with other types of disabilities was not an issue. This was perhaps the result of the long term institutionalization of many with retardation, epilepsy, blindness, mental health problems, and cerebral palsy. These disabilities by their very nature precluded using public transit. Travel by bus was too complicated and dangerous for individuals perceived to be unsophisticated and fragile. Those with other neurological, health, or hearing impairments were not considered as their needs were even less apparent. During this period, the ability to travel was understood to be something everyone knew how to do. It was not an acquired skill except for those with blindness.

The need for those congenitally blind or with acquired blindness to travel has been addressed for many decades. Certified Mobility and Orientation Specialists have been instructing the blind to travel independently with the aid of a white cane or guide dogs. Those with blindness have learned to travel because it was approached as a skill they could learn. Their blindness was accepted as a travel barrier which could be overcome. Sadly, except for some with retardation, this functional approach to meeting travel needs had not generalized to other disabilities. If the individual with a disability could not travel, it was because he had a disability. To expect more seemed both cruel and unrealistic.

THE COMMUNITY MOBILITY PROGRAM

In 1979, in Rochester, New York, a unique experiment was under way. Funds obtained from the Federal Highway Safety Administration were being used to develop a demonstration that applied the concepts of traditional mobility training for the blind to any disability or transportation handicap. In this generic form, skill was the key. The ability to travel as a pedestrian, public transit user, or bicyclist was accepted as a skill which could be taught and learned. Three modes of travel were task analyzed. Each step within these tasks was sequenced; a behavioral objective written; and a method for teaching described. This process resulted in a series of achievable goals that reinforced success throughout the learning process. The nature or cause of the skill deficit was relevant only in selecting different teaching methods. This curriculum was generic because it used the public transit system, an existing transportation resource, as the primary teaching tool in individualized travel skill training. Differences caused by disability were accommodated in the teaching process. The curriculum, evaluation, and teaching program were adaptable to anyone with any type of disability. The training process was consistent for anyone referred and included Evaluation, Individual Program Development, Orientation and Mobility Training, and Post-training Survey, each of which are discussed below.

The Evaluation Process was used to predict the probable success of the individual based on his competence in a few key prerequisite skills and a commitment to learn independent travel. The evaluation occurred in the community along the route(s) most likely to be traveled. All those referred were evaluated for their competence as pedestrians and then public transit or bicycle users as indicated. Additionally, the support of the family or significant other and the value of the travel goal to the learner were carefully assessed. The desire to travel independently often overcame barriers caused by disability, lack of experience, skill, or naivete'. The evaluation was on a Pass-Fail basis. Those demonstrating adequate skill in handedness, a concept of danger, the ability to follow three part directions, and socially acceptable behavior defined as, "the lack of extreme expression of any behavior which causes harm to self or others" were admitted into training. Those failing were recommended for a more appropriate type of transportation, e.g., taxi.

The Training Process began with the development of an Individual Training Program (ITP). Since most individuals referred to the Community Mobility Program had never traveled before, they were unfamiliar with the demands made by schedules, time, inclement weather, or bustling crowds. The trainee learned the requirements of travel,i.e., getting up on time, dressing appropriately for weather conditions, having the correct fare, and being at the bus stop on time. These new expectations were quickly included in the trainee's daily life routine. In addition to these orientation skills, the trainee had to acquire specific mobility and mode skills, e.g., how to use pedestrian safety aids, identify a landmark, or plan a route to a desired destination. These objectives were individualized from the Curriculum and included in the ITP. The unique learning needs,e.g., deficits in depth perception or short-term memory, inability to read or speak, poor matching skills, or number recognition, were accommodated in the teaching process.

Since learning to travel independently is a great deal of work, all trainees had to have a clearly identified goal for travel at the time they began training. The goal had to be something the trainee valued, usually a job, training program, or therapy session. They also had to make the commitment to travel at least three days per week. Both these conditions aided the trainee in re-orienting his daily life routine to include responsibility for his own transportation.

One of the most important skills a trainee had to acquire was how to cope with being lost. Four methods of coping with being lost were taught: 1) telephone for directions; 2) ask the bus driver for help; 3) ask a policeman for help; 4) stay on the bus. These methods were practiced and applied in different situations. The trainee was expected to gain competence in all methods except where counter-indicated (non-verbal trainees did not use the telephone). Post-training Survey data indicates that, when lost, former trainees employ the methods they were taught. Some generalize their skills and use their own solutions,e.g., walking home .

Some trainees needed special aides like a travel book or route card (for non-verbal or hard to understand persons) . These were individually prepared and the trainee taught to use them when asking directions or seeking help from a bus operator or police officer.

Throughout the average 18 to 24 hour training process, the trainee gradually assumed total responsibility for his/her travel. One-to-one instruction occurred on consecutive days over a two week period. Each training session included a two way trip. The Mobility Instructor began training by demonstrating sequenced tasks for the trainee,e.g., the safe point to cross the street with the walk light. The series of practice sessions required the trainee to assume more and more responsibility for the complete task. Competency was achieved when performance on the stated objectives reached 100%. Of those who entered training, 95%

completed their training program. Those who had to be discontinued usually fell into two categories: 1) family unable to support the trainee's gaining independence, 2) inability to achieve 100% performance on stated objectives. Most fell into the former, not the latter category.

One month following training, a Post-training Survey was administered to determine how well the new traveler was doing. Data from the survey were used to evaluate the training process for effectiveness and as justification for requests for financial support.(See Appendix)

Since June of 1980, when the Community Mobility Program initiated training, over 600 referrals for mobility training have been made and 400 have completed training. The post-training data indicate, for those responding, that 87% travel regularly; 79% are punctual; 70% use identification; and only 9% have been lost. Additionally, significant others (families, spouses, residental care staff) report that 42% have shown an improvement in their overall social behavior. Comments like "He's more responsible", "I don't worry about his handling money anymore", or "Its safe for her to be alone" are offered. It would appear that acquiring independent travel skills is a milestone that encourages adult behavior in other desired areas of development. Not only is the individual more in control of his daily life and able to make decisions regarding jobs, social contacts, and recreational activities, but families and the community are free to devote their transportation resources (time, money, creativity) to other uses. For the family, this may mean the ability to allow an adult-child to grow up; for the community it means expending scarce para-transit dollars on those not able to meet their travel needs in any other way. The independent traveler makes no demands for para-transit.

At the beginning of its demonstration, the Community Mobility Program focused its training on those with developmental disabilities as defined in Public Law 95-602. The vast majority of its referrals were for individuals with mental retardation. It was assumed that because these individuals had specific deficits in cognitive and adaptive skills only the highest functioning,i.e., those with mild mental retardation would be able to travel independently. Over the last four years, the Community Mobility Program has taught individuals with severe mental retardation and multiple disabilities to travel with success. This success led to the expansion of those served to include those with chronic mental health problems, learning disabilities, visual impairments, hearing impairments, epilepsy, neurological impairments, stroke, non-English speaking and the aged. Only those with orthopedic disabilities which prevent ambulation are restricted from admission to the Community Mobility Program.

The vast majority of those referred to the Community Mobility Program learn to use public transit. The cost of a one way trip on public transit in Rochester is $.70. The cost of a one way trip on Rochester's para-transit service is $7.26, of which $6.56 is subsidized. Community based transportation on agency vehicles is also approximately $7.00 per trip, of which the traveler usually contributes nothing. The Community Mobility Program's average training cost per trainee is $896. Following training the new traveler will spend approximately $360 per year for public transit. This is revenue collected at the fare box. The cost for one year of either para-transit or agency transit is over $3400. Financial support for these services comes from all manner of federal, state, and local funds. Many of these subsidies are over committed,e.g., Medicaid, or scheduled to terminate,e.g., Section 5. Generic mobility training offers a cost effective alternative to costly para-transit of any sort for many transportation dependent persons. The benefit in fare box recovery for the public transit authority is obvious. The reduction in demand for more expensive levels of transportation is reassuring. However, the greatest benefit is to the individual who learns to be responsible and meet his/her own transportation needs.

INFORMATIONAL PROGRAMS

Changing the travel behavior of so many persons with disabilities could not have been done without an extensive outreach effort to inform families, rehabilitation professionals, transportation providers, educators, funders, bus operators, and police officers about generic mobility training. In the first two years of the program over 2000 people were contacted with information about the Community Mobility Program. An inservice training program to instruct both bus operators and police on how to intervene should a traveler with a disability require assistance was developed. The cooperation of bus operators and police officials has been critical to the success of generic training in Rochester.

The full participation of the public transit operator and the inservice department of the police department were requested and obtained before development of programs proceeded beyond the concept phase. The formats for the inservices were specified by the Regional Transit Service and police department. In the case of the later, video tapes were produced on those disabilities the police officer was most likely to contact in the greatest number. In the case of the former, a live group presentation format was developed.

Video tapes for the police department were produced on those with mental retardation, cerebral palsy, and epilepsy. The tapes could be no more than four minutes in length. The copy and visuals were developed by the staff of the Community Mobility Program. The tapes were shot by police department staff. Editing was a joint responsibility. Since production, 465 officers have seen each of the tapes at least once. To augment the series, live group presentations on the services of the Community Mobility Program and the role the police officer plays in the community are annually made. The officers from the downtown section of the Rochester police department routinely interact with the trainees as they learn who to go to for help.

For the Regional Transit Service, the transit operator in Rochester, the inservice series called "Special People-Special Problems" was developed. Like the Community Mobility Program itself, this inservice has expanded to include information on those with all types of disabilities and the aged. All new drivers must take the two and one-half hour course. Other programs on specific areas of interest,e.g., the aged, are offered throughout the year on a voluntary attendance basis. A handbook providing information on the transportation handicapped has been jointly produced by the Community Mobility Program and the Regional Transit Service. This booklet is in its third printing.

The outreach effort of the Community Mobility Program smoothed the way for the newly trained traveler into the mainstream of the general traveling public.

SELF-SUFFICIENCY

Funds from the Federal Highway Safety Administration were allocated on a yearly basis for no more than three years. Once successful the Community Mobility Program had to develop a financial structure that would allow it to be self-sufficient. Efforts toward this end began eighteen months into the demonstration,after the viability of the training process had been sufficiently exhibited.

Possible sources of support on a fee-for-service basis were identified. The real cost of the program was computed on an hourly basis. The cost benefit of the program was carefully presented in a narrative form. During the next eighteen months the biggest challenge to be overcome was finding an organization with sufficient cash flow and a broadly based charter who would be willing to assume administrative responsibility for the program. The Genesee Transportation Council, the metropolitan planning organization, ultimately assumed this responsibility.

Four possible sources of funds to support a fee-for-service were identified: Medicaid, which pays for the cost of transportation for eligible clients to and from Medicaid approved programs; health insurance companies, which pay the cost of similar aid-to-daily-living services like occupational therapy; and the Office of Vocational Rehabilitation, which pays for a myriad of services for those with disabilities and a vocational goal; and private pay. The Community Mobility Program was successful in becoming a vendor to the Office of Vocational Rehabilitation. To increase its acceptance as a credible vendor with Medicaid and health insurance companies, Certified Orientation and Mobility Specialists replaced the original staff lost through attrition. Success with these two latter potential funders is yet to be achieved. Several trainees have been privately supported.

Other sources of revenue include local foundations which have provided considerable operating funds to the Community Mobility Program.

The transition from government support to self-sufficiency has been a difficult one. The greatest challenge for the program is to diversify its income base. It must convince various rehabilitation, planning, funding, and governmental units to include the cost of transportation whether vehicular, transit, or skill training, in their programs and budgets. This challenge reflects the continuing belief by decision makers that those with disabilities cannot be responsible for their own travel needs.

EXPANSION OF INDEPENDENT TRAVEL

The Community Mobility Program has demonstrated that most individuals who are transportation dependent can become independent if that is expected and taught. The concept of individual responsibility calls for a fundamental change in attitude on the part of the individual, the family, the social service provider, the funder, the transit authority, and the transportation planner. In the past, the approach has been to assume that transportation for those with disabilities had to be provided for the individual. Because he/she had a disability, the individual was not seen as able to assume this responsibility. This approach was logical given our understanding of the potential of those with disabilities for self-sufficiency. Most people with disabilities did not work, travel, or live in the community. Society had provided for them in large institutions which removed them from daily contact. With the decline of institutions as a solution to the needs of those with disabilities, the expectations for those with disabilities has gradually changed. It is now common to expect those with all types of disabilities to maintain a normal life routine of work, recreation, social interaction, and travel. Our solutions to meeting the transportation needs of those with disabilities must keep pace. As with other citizens, the responsibility for transportation should lie with the individual whenever possible. His/her ability to be independent should be considered at the outset. A continuum of transportation options can be made available with the cooperation of all sectors of the community. The cost of transportation must be included in all programs and services. As with transit, there will be no large resources of new dollars to meet the transportation needs of the disabled. Most importantly the responsibility for moving away from transportation dependence to independence must be shared by everyone. In this way, those able to use public transit will do so and those needing para-transit will more likely have it available.

Appendix

COMMUNITY MOBILITY PROGRAM

INDIVIDUAL MOBILITY POST-TRAINING QUESTIONNAIRE RESULTS

193 respondents of the 326 individuals
trained during 7/1/80 to 3/31/83)

Travel Skill	Regularly	Seldom	Never
Travel independently as trained	168 (87%)	11(6%)	24 (12%)
Punctual behavior	153 (79%)	1 (1%)	10 (5%)
Carries identification	135 (70%)	3 (2%)	16 (8%)
Uses travel book (if needed)	38 (58%)	3 (5%)	25 (37%)

Travel Associated Skill	Yes	NO	No Response
Became Lost	17 (9%)	150(78%)	26 (130%)
As trained, coped by:			
- using the telephone	7		
- talking to police	4		
- talking to bus driver	4		

Improvement in Overall Social Behavior	Yes	No	Didn't Know
	81 (42%)	88 (46%)	24 (12%)

Public Transport Usage By the Active Elderly Holding Free Travel Passes

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Abstract

The paper reports on the findings of a survey conducted in 1983 of the use made of public transport services in the West Midlands Passenger Transport Executive area by elderly people, who are entitled to the free use of bus and suburban railway services during off peak hours.

Respondents to the survey all lived in urban surroundings, often in locations where both train and bus services were available. None were housebound, and few had a car available. The majority lived alone.

Two major general findings emerged from the study:

Firstly, the elderly had a marked preference for bus services rather than rail services, when both were free, because of the shorter walking distances associated with bus travel, and the greater likelihood of having to climb staircases at railway stations. This preference was despite the fact that better waiting facilities were associated with rail travel. Numerous respondents had difficulty in boarding buses, but not trains.

Secondly, the majority of the elderly had a local shopping centre including a post office and a chemist, within walking distance, yet regularly travelled to a more distant district shopping centre for their everyday needs. Clearly, the elderly wish to exercise the independence, and the greater choice, that concessionary fare schemes can offer.

1 Background

1.1 The general rationale for the provision of free or cheap travel for the elderly is well known. Public transport can provide an essential lifeline for the non-car owning elderly. At off-peak times, a use should be found for the buses used at journey-to-work times by fare-paying commuters.

1.2 This has provided the basic justification for the granting of free, or reduced fare tickets for the elderly in many large urban areas. One such area is formed by the West Midlands conurbation, where since 1974 free travel passes have been available to the elderly after 9.30 and before 15.30. The West Midlands is a conurbation of some 2.5 million population. Formerly a prosperous manufacturing region, heavily reliant upon metal processing industries, it has in recent times become an area of rising unemployment.

Car ownership, once above the national average, has not risen as predicted in the 1960's, and 40% of households in Birmingham were without a car in 1981. In recent years, there has been some thinning out of central area employment, leading to a reduction in total travel to the central core. Most public transport usage is by bus, but there are a number of suburban railway lines. Politically, the West Midlands are under labour control, and the County Council have attempted to upgrade public transport, and to develop the suburban railway network, by improving train frequencies etc.

1.3 The provision of free travel passes for the elderly has had a beneficial effect upon bus passenger boarding rate after 9.30 a.m., as may be seen from the following table.

BUS PASSENGER BOARDING RATE PER HOUR (Thousands)

	1979/80	1980/81	1981/82	1983/83	% Change 1979/80 to 1982/83
WEEKDAYS					
Morning Peak	147	139	138	127	-14%
0930-1530	106	106	113	106	no change
Evening Peak	148	138	144	132	-11%
1800 onwards	48	41	44	36	-25%
WEEKDAYS	96	91	94	92	-4%
SATURDAY	83	72	67	64	-23%
SUNDAY	41	39	33	26	-37%
WHOLE WEEK	88	83	83	77	-13%

Source: Reference 1

Whilst the 'shopping' sector of the passenger transport market has maintained usage most successfully in relation to other sectors (e.g. the sharp decline in evening social travel), there can be little doubt that travel by pensioners has contributed substantially to the strong demand for bus travel between 09.30 and 15.30. Since these figures were published, travel during the evening peak has also been made free, with further beneficial effects upon bus usage by the elderly.

Whilst pensioners made up 20% of all passengers carried, in the off-peak the proportion rises to 30% (Ref. 2). Currently, the West Midlands Passenger Transport Executive carry 1,976,000 pensioners weekly. This is an increase of 190,000 following the change in validity of free passes permitting evening peak hour free travel, which occurred on Jan 1st 1984. The increase is of 103,000 journeys during the peak, but also 87,000 during the off peak.

1.4 The travel passes have been in operation since 1974, and during that period the West Midlands Passenger Transport Executive, who are also responsible for local rail transport, have attempted to integrate bus and rail services and fares. Rail forms a small but rising proportion of the total passenger journeys.

WMPTE Integrated System Passenger Statistics

Passenger journeys (Millions of passengers)	1978/79	1979/80	1980/81	1981/82	1982/83
PTE Bus	528.6	528.1	494.7	500.0	457.8
Other Bus	14.1	10.6	9.8	9.1	8.3
Total Bus	542.7	538.7	504.5	509.1	466.1
Local Rail	21.1	23.8	22.0	22.5	20.0
Total Bus and Rail	563.8	562.5	526.5	531.6	486.1

1.5 Rail usage by pensioners is likewise small by comparison with bus usage. During the year April 1983 to March 1984 there were 2.75 million rail journeys by pensioners. This represents an increase of 27% over the previous year. Prior to the extension of validity of free travel passes, pensioners made up 10% of all rail passengers: after the change this proportion rose to 12% (Ref. 2).

2. Pensioner travel by bus and train in Birmingham

2.1 The travel needs of 3 specific groups of pensioners were studied in a survey undertaken in 3 suburbs of Birmingham in 1983 (Ref. 3). This found that:

i) 82% of the elderly required transport for non-local shopping trips.

ii) 49% of the elderly required transport for access to a day centre or community centre.

iii) 18% of the elderly required transport for non-local medical trips.

iv) 51% of the elderly required transport for social visits.

These requirements must be seen against what apppears to be a very good level of local service provision in the 3 sample areas surveyed.

2.2 Access to shops

57% of the elderly could reach the nearest shopping facilities from their home, with less than 10 minutes walk. Yet only 18% of the elderly did their main shopping at those local shops.

Some 43% did not use their most local shops at all. 78% of respondents went to district shopping centres by bus.

2.3 Access to Post Offices

The state pension can be obtained by pensioners either by weekly collection from a post office, or through a bank account. The survey sampled found all pensioners collected their pensions weekly, from the Post Office. 87% of pensioners had their nearest post office within 15 minutes walk. However, a clear majority of pensioners collected their pension from a district centre, in many cases in combination with a shopping trip.

2.4 Access to Community Centres

The average journey length to community centres was only .68 miles - less than to shops or medical facilities. This short distance is reflected in the importance of walking as a means of access to such centres:

51% walk
41% bus
4% car
4% train

Car ownership among the sample was low, and only 38% stated that they regularly received lifts (generally from relatives). This reflects the

Transport and Road Research Laboratory finding (Ref. 4) that car travel accounts for a significant proportion of the journeys made by the elderly only where they live in a household with a car.

Strangely, the actual travel by car by pensioners in this sample suggested a much lower level of car usage than perhaps implied by the 38% "regularly receiving lifts".

By far the most predominant mode of transport was the bus accounting for 94% of travel over .5 mile.

2.5 Access to bus stops

Pensioners surveyed were asked how long it took them to reach the nearest bus stop.

Access time to nearest bus stop:

Time	Respondents
1 - 3 minutes	58%
4 - 5 minutes	20%
6 - 10 minutes	20%
11 - 15 minutes	2%

These figures are surprising, but it should be borne in mind that they represent perceptions of time, rather than observations of actual movements. If the elderly feel they have plenty of time, then perhaps that walking time has a low valuation. Nevertheless, when pensioners were questioned about problems with public transport, 24% referred to the "long wait" for the bus or train to come.

The 3 sample areas were chosen in areas served by suburban railways, so as to allow for the possibility of choosing rail travel as an alternative to bus. Even so, rail usage was very low. There were fewer complaints about rail travel itself: notably there was an absence of complaints about the vehicle jerking: a characteristic of buses found unsatisfactory by some respondents. Shared by both bus and railway services was the step-climbing problem, cited by 24% of respondents. However, the general preference for the bus seems to lie in its better suitability for short inter-suburban journeys.

3. Policy implications

3.1 Even if many new rapid transit lines were built in an area such as the West Midlands, the level of coverage that could be provided (in terms of average walking distance to stations) would be inferior that that provided by the present bus network.

Methods to avoid access problems for the elderly at stations can, at least, have partial success. Ramps are not an ideal alternative to steps. The provision of lifts at stations is incompatible with the most feasible form of rapid transit - i.e. light rapid transport, where the emphasis is upon simplicity of facilities. The lavish facilities for the elderly and disabled on systems such as the Washington Metro are clearly only possible on the most expensive of systems, normally found in capitals, where prestige is an important element in the decision process. The number of level changes at stations does depend upon the ticket collection arrangements. Traditional, and some recent metro layouts have ticket barriers at an intermediate mezzanine level.

3.2 Systems such as the Lyon metro, which have open stations and rely on vehicle inspection of tickets, have no need for a mezzanine level. Thus access to the Lyon metro - built by the cut-and-cover method, often below city centre streets reserved for the exclusive use of pedestrians, can be very direct, and therefore less likely to cause problems for the active elderly.

3.3 Another factor concerns the usage of the city centre by the elderly. The evidence suggests that while the elderly are happy to board a bus to reach a shopping centre, it is the nearest district centre, rather than the city centre, that serves as the destination (see average trip length figures below). Typically, district centres can provide the range of facilities most used by the elderly: shops, chemists and community centres or day centres. The city centre of Birmingham, while of course providing a much greater range of shopping facilities, does not provide the community facilities to be found in district centres. Whilst the major library is to be found in the city centre, the much smaller libraries to be found in district centres - in public branch libraries and in day centres - are possibly of more value to typical pensioners.

3.4 It is widely held that there is a social role of very local shopping facilities, of particular value to non-car owners such as the majority of elderly. This study suggests that such local shops, in decline over a long period because of competition from newer forms of retailing, may have their future further undermined in cities where local pensioners can enjoy the benefits of free travel passes.

The usage figures from rapid transit services and suburban railways suggest that rapid transit is most successful in moving people to city centres.

Bus usage is less biased towards city centre destinations, being more used for shorter, inter-suburban journeys.

It seems, therefore, that arguments in favour of development of urban railways, or new rapid transit, are unlikely to be supported in terms of benefits to the elderly.

In the West Midlands, the 1982/83 average trip length for all travel, was 4.49 km by bus, and 11.54 km by rail.

Among the elderly the average trip length is slightly shorter. 75% of journeys by the elderly, are in 1984, of fewer than 5 stages (1 stage equals approximately 1 km) (Ref. 2).

One argument sometimes used in favour of rail based public transport investment is that rail-based transport has been demonstrated to be attractive to car-owners (given appropriate levels of congestion, parking charges etc) whereas bus public transport is less able to be made attractive to car owners. The survey of pensioners in Birmingham did not enquire as to whether the respondents had at any time in the past, been car drivers.

In future, many more pensioners may be people who have previously been used to the convenience of car travel. The present level of bus usage by pensioners is high, and could be interpreted as showing a degree of enthusiasm for free travel passes, indicated by the relative neglect of the nearest local shopping facilities. For car-owners to adjust their travel expectations, following the loss of their driving licences as a result of growing fraility, may be hard. In the U.K. driving licences are valid to the age of 70, and are then renewable on a short term basis, according to fitness. For pensioner's with car-dependent travel expectations a free travel pass, whether on bus or rail, or both, may not seem to be enjoyed with quite the same enthusiasm apparently manifest in the travel patterns of today's elderly in the West Midlands.

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MULTIPURPOSE VEHICLES AS A SOLUTION TO THE NEED FOR TRANSPORTATION OF THE ELDERLY AND HANDICAPPED IN SMALL AND ISOLATED COMMUNITIES

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MULTIPURPOSE VEHICLES AS A SOLUTION TO THE NEED FOR TRANSPORTATION OF THE ELDERLY AND HANDICAPPED IN SMALL AND ISOLATED COMMUNITIES

by

Jim Wallace and John C. Rea

A key element in bringing the elderly and handicapped into the mainstream of community life is the provision of adequate transportation services. In recent years there have been a number of advances in this field but they have been largely confined to urban areas or heavily populated rural areas. To meet the need for transportation of the elderly and handicapped in lightly populated rural areas the Province of Manitoba introduced a program of assistance to communities designed to meet the unusual demographic characteristics of the province.

Since the turn of the century there has been a shift to urban living so that some 70 percent of Manitoba's population now lives in a few large urban centres and the remainder on farms or in small communities throughout the province. Outside the City of Winnipeg, which has over half the province's population (578,000), and a few small cities such as Brandon (34,901), Thompson (17,291) and Portage la Prairie (12,555), there are few local public transportation facilities and even local taxis are rare. The existing rural program encompasses thirteen communities with service being provided to contiguous rural municipalities. This program has been largely confined to the southern agricultural area of the province with no services operated in the isolated northern communities.

A challenge that has fascinated the administrators of the province's rural program from its beginning is the question of the minimum size settlement in which a transportation service for the elderly and handicapped can be justified. While it is evident that Manitoba is providing service in communities much smaller than considered feasible in other jurisdictions, there are realistic limitations to what can be done. It has been widely accepted that the establishment of transportation services for the elderly and handicapped is feasible only in those areas where there is a sufficient user population to justify the purchase and operation of a vehicle and a tax base sufficient to support the service. This would lead one to conclude that service cannot be provided to all small or isolated communities, particularly those in the north.

The introduction of measures designed to keep costs down can help make service viable in small communities. Experience with the existing program in rural communities has shown that where overheads such as accommodation and communications can be shared service can be provided in areas where it would be otherwise unlikely to survive. The use of properly qualified volunteer drivers and other staff can also reduce costs significantly. The greatest potential, however, may be found by integrating the service with another program.

In addition to supporting transportation services for the elderly and handicapped in rural areas, the province provides support for local ambulance services through the Emergency Health and Ambulance Services section of the Manitoba Health Services Commission. Of the seventy ambulance services which were operating in 1982, twenty-seven reported less than 100 calls and the lowest usage was seven calls for the year. In addition, there were many other small or isolated communities which had some need for ambulance service although the demand was considered insufficient to justify provision of a dedicated vehicle. Many of the communities with a low incidence of ambulance calls and many of those without ambulance service also have a need for a vehicle cabable of transporting the elderly and handicapped, including those in wheelchairs. It is considered that if these needs can be combined and met by a single vehicle a service can probably be justified.

Any suggestion that an ambulance be given other roles immediately causes concern and raises a number of questions:

1. Is it feasible to fill both roles with a single vehicle?
2. Is the vehicle likely to be available when required for its emergency role?
3. Will the dual roles require modifications to the vehicle which will adversely affect the ability to perform the ambulance function?
4. Will the use of a single vehicle for two services create administrative problems?

The first question is easily answered. There are no technical problems in designing a vehicle that is an ambulance as well as a vehicle for transportation of the elderly and handicapped. The floor plan for such a vehicle designed by Crestline Coach is shown in Figures 1 and 2. The floor plan shown offers the following combinations:

WHEELCHAIRS	MAIN #26 STRETCHER	PASSENGER SEATING
1	0	7
1	1	4
1	2	1
2	0	3
2	1	0
0	0	8
0	1	5
0	2	2

The two wheelchair positions have dual purpose (flip-up) seats which can be used for ambulatory passengers or an ambulance attendant. The two flip up bench seats in the rear of the vehicle have a capacity for six ambulatory passengers. With these seats folded up there is room for two FW26 stretchers, side by side, in the rear of the vehicle.

FIGURE 1

Floor Plan of Multipurpose Vehicle

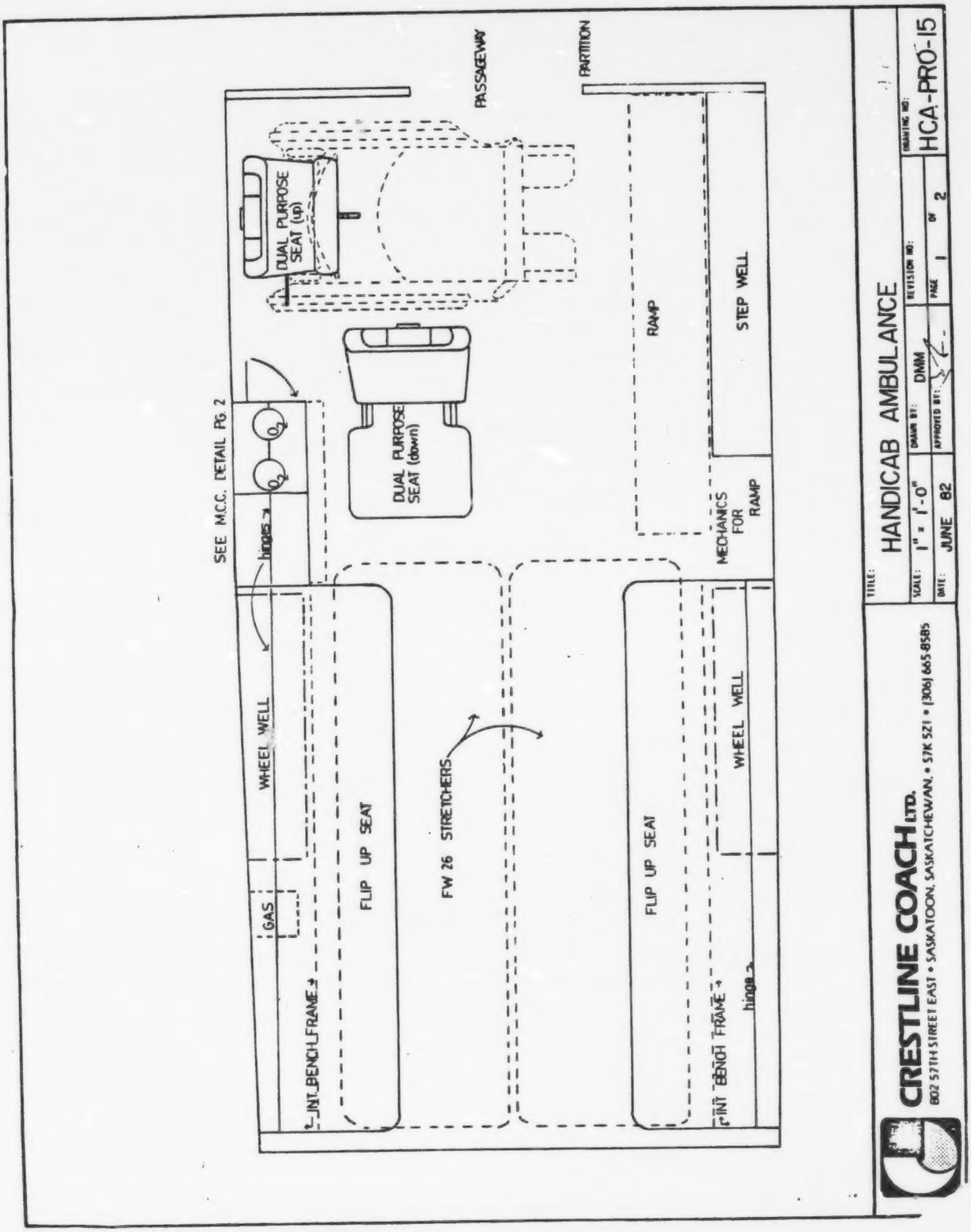
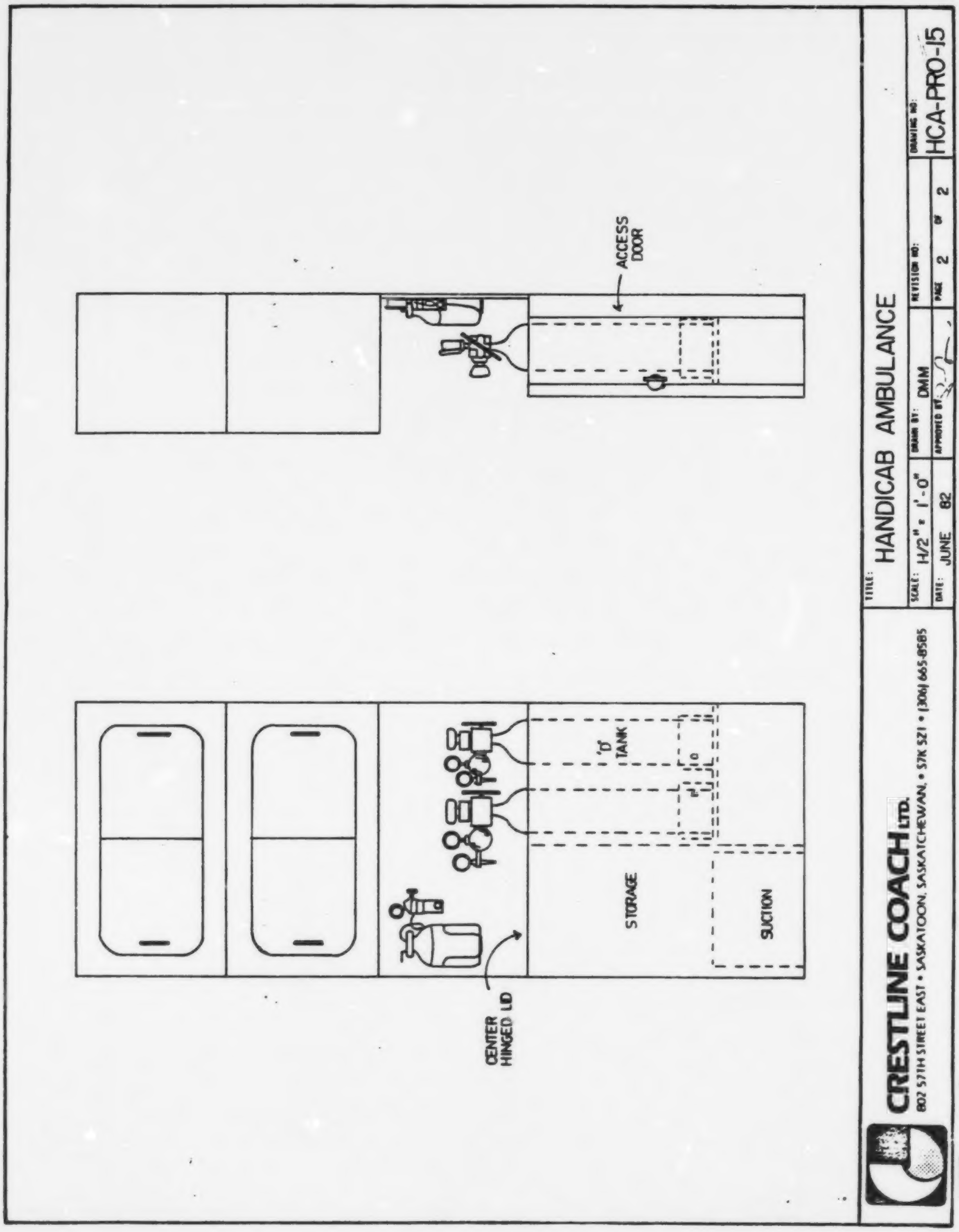

PASSAGEWAY
PARTITION
DUAL PURPOSE SEAT (up)
DUAL PURPOSE SEAT (down)
RAMP
STEP WELL
SEE M.C.C. DETAIL PG. 2
hinges
O_2
O_2
MECHANICS FOR RAMP
WHEEL WELL
FLIP UP SEAT
FW 26 STRETCHERS
FLIP UP SEAT
WHEEL WELL
GAS
INT. BENCH FRAME
INT. BENCH FRAME
hinge
TITLE: HANDICAB AMBULANCE
SCALE: 1" = 1'-0"
DATE: JUNE 82
DRAWN BY: DMM
APPROVED BY:
REVISION NO:
PAGE 1 OF 2
DRAWING NO: HCA-PRO-15
CRESTLINE COACH LTD.
802 57TH STREET EAST • SASKATOON, SASKATCHEWAN • S7K 5Z1 • (306) 665-8585

FIGURE 2

Life Support Equipment Storage Area


CENTER HINGED LID
STORAGE
SUCTION
'D' TANK
ACCESS DOOR
CRESTLINE COACH LTD.
802 57TH STREET EAST • SASKATOON, SASKATCHEWAN, • S7K 5Z1 • (306) 665-8585
TITLE: HANDICAB AMBULANCE
SCALE: 1/2" = 1'-0"
DRAWN BY: DMM
REVISION NO:
DRAWING NO: HCA-PRO-15
DATE: JUNE 82
APPROVED BY:
PAGE 2 OF 2

A cabinet mounted on the left side by the rear facing dual seat will provide space for two "D" or "E" size oxygen bottles, flowmeters, electric suction unit and first aid and medical supplies. Swtiches for the operation of suction pump, rear heater and other lights and equipment for patient care will be mounted in this area readily accessible to an attendant.

The vehicle itself can be a modified standard commercial van but must be the heaviest available model due to the weight of the raised roof, the lift and additional equipment in addition to passengers and the driver. The design must be such that it is not necessary to raise the stretcher very high to load or unload. Ideally, the height from the ground to the rear floor of the ambulance should not be more than twenty-six inches.

The vehicle should produce a soft, stable ride without undue discomfort to the patients or passengers in the vehicle. In actual practice, however, some ride quality may have to be sacrificed to provide the springing necessary to operate over unimproved roads in remote areas. In any case the right hand springs will have to be adjusted to eliminate sag due to the lift installation.

The two dual purpose seats will be equipped with wheelchair restraints and seat belts. The unit will convert instantly from a wheelchair lock-in device to a seat without requiring any adjustment. The flip-up bench seats at the rear will be equipped with standard seat belts and will have a storage area accessible when the seat is in the raised position.

This design will provide a utilitarian vehicle capable of providing local ambulance service and, at the same time, meeting the needs of elderly and handicapped residents including those in a wheelchair. It thus seems obvious that it is feasible to have one vehicle fill both roles, but the question of availability must still be addressed. In examining the 1982 data it was noted that there are twenty-seven communities that had fewer than 100 calls for their ambulance that year. The highest number of calls was for Hamiota which had 92 calls or an average of one call each 3.97 days. The lowest were Bissett and Baldur with 9 calls or one call each 40.55 days. The average for all twenty-seven communities was one call each 6.66 days. Since ambulance calls come round-the-clock and elderly and handicapped transportation is normally restricted to day and evening hours the likelihood of a conflict in calls is relatively small.

In some cases rural ambulance services make lengthy journeys taking patients to Winnipeg or other major centres. In these cases the local ambulance may be gone for a considerable time and the community must either go without ambulance service or obtain coverage from a nearby community. It is considered that it would not be reasonable to try to operate a combined service in communities where the ambulance/handivan might be called away for lengthy periods on short notice. The multipurpose vehicle design incorporates minimum life sustaining equipment and is not the optimum vehicle for long distance patient transportation. It should be noted, however, that in those locations where there is no backup ambulance service available from neighbouring communities a dual purpose vehicle would provide an ideal backup.

There is an extensive administrative organization for the operation of rural ambulance services with delivery of the service being in the hands of local government. The Manitoba Health Services Commission has introduced a communications system and driver training standards and has developed a province-wide network based largely on volunteer drivers. The program for the transportation of the elderly and handicapped is administered by the Department of Highways and Transportation but it too places program delivery in the hands of local government. There is constant liaison and cooperation between the two departments and at the local level the programs are often delivered by the same individuals. From experience it would appear that there should be no problem introducing a multipurpose vehicle at the local level.

Having concluded that it is feasible to fill both roles with a single vehicle it is necessary to establish criteria for the selection of communities where such service is feasible, then develop operating criteria to minimize the risk of interference with the primary purpose of the vehicle.

In establishing criteria for communities where such service is feasible we can divide them into two categories:

1. those which now have ambulance service but no elderly and handicapped transportation service; and

2. those having neither ambulance nor elderly and handicapped transportation service.

For those communities with ambulance service but no elderly and handicapped transportation service the following basic criteria are suggested:

1. the community ambulance should not be required for long distance patient transportation thus making the use of a minimal ambulance acceptable;

2. the demand for ambulance service should be sufficiently low to provide an acceptable risk that the ambulance will not be immediately available; and

3. the radius of operation should be such that when called by radio the driver could deliver his elderly or handicapped passenger to a place where they can be adequately cared for and then respond to the ambulance call.

After due consideration it was decided that use of a dual purpose vehicle in communities having 50 or less ambulance calls per year (approximately one per week) would be an acceptable risk. Other communities which do not meet these criteria but have a demand for elderly and handicapped transportation may consider introduction of a dual purpose vehicle as a second vehicle to provide backup for the primary ambulance as well as handivan service.

The most exciting area and that with the greatest potential is in those communities having neither ambulance service nor transportation for the elderly and handicapped. These small and remote communities cannot support either ambulance or handivan service but could, possibly, support a combination.

The criteria for establishment of service in such cases could include:

1. existence of a hospital, nursing station or care facility on which service can be based;
2. an established need for wheelchair and ambulatory transportation for the elderly and handicapped; and
3. a restricted radius of operation with no long highway trips.

This would allow the provision of local transportation for the elderly and handicapped in very small communities, where it would otherwise be impossible to consider such service. As an example, there could be a multipurpose vehicle in an isolated northern village so remote that it is not even connected to the provincial highway system.

The concept of emergency ambulance service often dictates that there will be very low vehicle utilization. The concept of the multipurpose vehicle converts this underutilized capacity into transportation service for the elderly and handicapped. Manitoba has pioneered innovations in bringing elderly and handicapped transportation services to rural areas. The multipurpose vehicle concept can provide the solution to the problem of extending such service to small and isolated communities.

SECTION 504 REGULATIONS: HISTORY AND FUTURE IMPACTS

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October 29-31, 1984

Section 504 Regulations: History and Future Impacts

The intent of the present discussion is to review the major points in the development of Section 504 of the Rehabilitation Act of 1973 and the subsequent efforts at implementation of that section in the field of public transportation. Additionally, ten publicly funded providers of transportation for the handicapped are reviewed with respect to the anticipated impacts of the new Urban Mass Transportation Administration's (UMTA) proposed Section 504 requirements.

The Legislation

The legislative history of efforts to improve mobility of elderly and handicapped citizens is rather simple and straightforward. The White House Conference on Aging in 1971 and a series of preceding and succeeding conferences addressing the mobility problems of the elderly and the handicapped provided the broad support base necessary to spur the United States Congress into passage of a series of amendments and statutes which had the intent of improving the mobility of the elderly and the handicapped.

With respect to the field of transportation, the major Congressional actions were Section 504 of the Rehabilitation Act of 1973, Section 16 of the Urban Mass Transportation Act of 1964 as amended and Section 165 of the Federal-Aid Highway Act of 1973 as amended. For the present purposes the legislation of primary interest is Section 504 of the Rehabilitation Act of 1973.

Section 504 states:

> No otherwise qualified handicapped individual in the United States shall, solely for the reason of his handicap, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance.

While the section is specifically targeted to the handicapped, in actuality the impacts of the section are closely tied to transportation of the elderly as well.

Given the broad support for this legislation and the skillful lobbying efforts of the representatives of the handicapped community, the legislation itself did not produce a major controversy. The debate prior to passage addressed little attention to the costs of implementation or to the long term implications of the statutes. Indeed, the legislative history is relatively brief and offers little guidance for subsequent efforts at implementation.

Implementation Efforts

Table 1 displays a brief history of the major activities concerning the Section 504 requirements. As can be observed, several activities occurred at the same time in apparent disregard of each other.

However, before reviewing the implementation efforts directly flowing from Section 504, a review[1] of the guidelines implementing the so-called Biaggi amendments is in order. The Biaggi amendments (named after a major Congressional supporter) to the Urban Mass Transportation Act of 1964 (Section 16(a)) required that special efforts to serve the transportation needs of the elderly and the handicapped populations be made by recipients of federal transit assistance funds.

TABLE 1: CHRONOLOGY OF SECTION 504 IMPLEMENTATION ACTIVITIES

1973	Passage of Section 504
April 1976	DOT issues guidelines for Biaggi amendments (not directly 504 related); first use of 5% guideline and special efforts requirement.
April 28, 1976	Executive Order 11914 directs HEW to establish goverment wide Section 504 guidelines.
February 1977	First accessible bus service (San Diego)
April 1977	Handicapped Sit-in at HEW offices
May 4, 1977	First HEW government wide regulations regarding Section 504
May 19, 1977	Transbus regulations (UMTA)
January 13, 1978	Final HEW government wide Section 504 Guidelines
June 8, 1978	DOT issues proposed rule making on Section 504 regulations
January 1979	First bid request for Transbus
May 31, 1979	Final DOT Section 504 Rules - includes 2% rule for interim service and wheelchair lift requirements
June 29, 1979	APTA sues DOT
August 1979	Transbus delayed
February 1980	APTA receives adverse ruling in lower courts
May 26, 1981	Appellate court rules DOT exceeded its authority under Section 504
July 20, 1981	Interim Final Rules published by UMTA; 3.5% rule established
December 1982	Section 317(c) of the Surface Transportation Assistance Act mandates the issuance of final Section 504 rules
September 8, 1983	Proposed Final Regulations published by UMTA
January 1984	Review of comments and development of final rules begins

In April of 1976, the Department of Transportation issued guidelines for meeting the special effort requirements*. These guidelines permitted several alternatives, the most widely accepted was the expenditure of an amount equal to 5% of a recipient's Section 5 funds on special effort activities. It was not required that actual Section 5 funds be expended, just that an amount equal to 5% of those funds be expended regardless of the source of the actual dollars utilized.

Alternately, a system could make 50% of its bus fleet accessible by means of wheelchair lifts or a system could provide ten trips per week to the semi-ambulatory or to the wheelchair bound.[2] Of these options, the 5% rule was the most straightforward and the most widely accepted. Even though this was not part of the Department's 504 effort per se, these guidelines became interwoven with subsequent 504 regulations.

With respect to regulations directly flowing from Section 504, Executive Order 11914, April 28, 1976, instructed the Secretary of

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*Following public meetings during November 1974, the Department issued proposed rules for implementation of Section 16(a) of the Urban Mass Transportation Act of 1964, as amended, and Section 165(b) of the Federal-Aid Highway Act of 1973, as amended. The proposed rules, published on February 26, 1975, underwent further modification to become the final rules of April 1976. While citing Section 504 as part of the Department's authority to issue the proposed rules (1975), the "Codification of Requirements" cite only Section 16(a) and Section 165(b). On October 20, 1976, the Department published its proposed policy on Paratransit Services which basically said that paratransit should be encouraged but, again, made no reference to Section 504. Thus, for the present purposes, these proposed and finalized policies and rules are not considered to be part of the Department's 504 efforts per se, but part of the Section 16(a) and Section 165(b) special efforts activities.

Health, Education and Welfare to issue government wide regulations for implementing Section 504. However, no meaningful action occurred until April of 1977 when members of the handicapped community staged a sit-in at the Department of Health, Education and Welfare's (HEW)* headquarters in Washington, DC, as well as at several regional offices. The demonstrations were prompted by HEW's non-action regarding regulations for the implementation of the Section 504 requirements during the Nixon and Ford administrations and a disagreement over the need for a Carter administration review of existing draft regulations. After discussions with the demonstrators, agreement was reached and HEW issued interim regulations on May 4, 1977.

The HEW regulations set forth government wide policy with respect to implementing Section 504. Each department and agency in the government was then required to develop regulations specific to its programs which were in-line with the HEW prepared government wide regulations. This discussion focuses upon the regulations issued by the Department of Transportation and, in particular, those impacting bus and paratransit services.

In a related matter, the first accessible buses in the United States were placed into service in San Diego, California, in February 1977. St. Louis, Missouri followed with accessible buses in August

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*Now the Department of Health and Human Services (HHS). When HEW was dissolved, responsibility for government wide guidelines for Section 504 was transferred to the Department of Justice (DOJ) (Executive Order 12250).

1977. These early efforts at providing handicapped mobility by means of accessible fixed route transit have importance because they provided the first indication of the costs and utilization levels associated with this approach to fulfilling the intent of Section 504. These early experiences revealed high cost and realtively low utilization rates. Two factors which continue to be major considerations in the implementation of Section 504.

In May of 1977, UMTA introduced a regulation which continues to confuse the history of Section 504. This was the Transbus regulation. While not a response to Section 504 and while not requiring full accessiblity[3] (wheelchair accessibility was optional, for example), the Transbus effort is often viewed, incorrectly, as part of the Department of Transportation's 504 response.*

Meanwhile, the Department of Health, Education and Welfare issued its final Section 504 guidelines in January 1978. These guidelines took the position "that any federally-funded program or activity, when viewed in its entirety, must be readily accessible to, and usable by, handicapped persons."[5] This established the concept of program accessibility which continues to be a main focus of the Section 504 requirements. On June 8, 1978, the Department of Transportation issued a proposed rule making on Section 504. However, almost one year elasped before the final rules were published.

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*While the Section 504 regulations continued to be promulgated, the Transbus saga also went on. In January 1979, a consortium composed of Los Angeles, Miami and Philadelphia requested bids on 530 Transbuses. No bids were received from domestic manufacturers. In light of this reality, the Department of Transportation temporarily delayed the Transbus regulations on August 3, 1979. The delay became permanent,[4] and Transbus became a dead issue for all practical purposes.

The Department of Transportation issued its final 504 rules on May 31, 1979. For fixed route transit, these regulations required:

- for purchases after July 2, 1979, all public transit buses must be accessible and include wheelchair access.
- within three years, fixed route transit must have program accessibility and 50% of the peak hour fleet must be accessible within ten years.
- if the above can not be accomplished within three years, then some form of interim accessible service must be provided and that the interim service must have certain specified comparabilities to the fixed route service. If this approach is adopted, then at least 2% of the system's Section 5 funds must be spent on the interim service.[6]

Shortly after the issuance of the May 1979 regulations, the American Public Transit Association (APTA) filed suit to prevent the enforcement of the regulations. In particular, APTA objected to the wheelchair accessibility requirement because of the high costs associated with that requirement. In February 1980, the federal court ruled against APTA. However, upon appeal, APTA obtained a ruling,* on May 26, 1981, that the Department of Transportation had exceeded its authority in requiring wheelchair lifts.

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* American Public Transit Association v. Lewis, 556 F.2d 1271 (D.C.Cir., 1981).

The Court based its ruling primarly upon a U.S. Supreme Court ruling (Southeastern Community College v. Davis, 442 U.S. 397 (1979)) which held that Section 504 does not require modifications which fundamentally alter the nature of a program. In the same case, the Supreme Court held that changes which result in "undue financial and administrative burdens" are not required by Section 504. While the U.S. Court of Appeals did not void the regulations in question [Subpart E of 49 CFR Part 27], it did remand the matter to the Secretary of Transportation to determine whether or not statutory authority other than Section 504 existed which would support the questioned requirements.

While the suit was in process the situation continued to be debated within the Congress and the transit community with growing support for local option; i.e., the ability of local areas to determine the methods by which transportation for the handicapped would be provided (fixed route accessible, accessible paratransit or some combination).

During the 1980-1981 Congressional session support for the local option approach found its way into amendments to the 1980 Surface Transportation Act. However, the session ended before enactment of the legislation.

The new administration which arrived following the 1980 presidential election established a Presidential Task Force on Regulatory Relief. This task force gave priority review status to the Department's 1979 rules. In response to this review, the Department took the position that the handicapped must be provided with transportation services by recipients of federal assistance but that the local communities have the "major responsibility" for determining the form of the transportation services provided.

After the Department established the above policy and after the receipt of the final court ruling, the Department issued interim final rules in July 1981. The interim final rules removed those sections from the 1979 final rules which had been the subject of the court action and reinstated the special efforts requirement first introduced in 1976 in response to Section 16(a) of the Urban Mass Transportation Act and Section 165(b) of the Federal-Aid Highway Act. The 1981 rules modified the 1976 requirement of expending 5% of a recipient's Section 5 funds on special efforts. These 1981 rules imposed a financial level of effort criteria equivalent to 3.5% (an amount judged equivalent in 1981 to 5% in 1977, the first full fiscal year of the 1976 rules) of the recipient's Section 5 funds. The recipient may count the expenditures of other operators (Section 16(b)(2) recipients and human service operators) toward the 3.5% amount when these special services meet certain requirements including accessibility.

The circumstances remained unaltered until the passage of Section 317(c) of the Surface Transportation Assistance Act in late 1982. This section required the Department of Transportation to issue permanent regulations dealing with handicapped persons' access to transit buses (rail services were not included). In accord with this requirement, UMTA issued proposed final regulations on September 8, 1983. These proposed requirements, which have not been finalized as of this writing, permit the local recipients of UMTA funding to fulfill the Section 504 requirements by a 50% accessible bus fleet, by provision of specialized transportation services, or by some combination. These proposed regulations are reviewed in more detail in the following section.

The Currently Proposed Final Regulations

The currently proposed final regulations grew out of a concern by members of the U.S. Senate that the interim final rules were permitting widespread deficiencies in paratransit services for the elderly and the handicapped. The deficiencies cited included such items as trip priorities, advance reservation requirements, waiting lists for service, delays in service delivery and restricted service areas, to note but a few of the major topics of concern.

The Congress held the view that these deficiencies arose from the interim final rules of 1981. Thus, Section 317(c) of the Surface Transportation Assistance Act of 1982:

> directs the Department to change its approach to implementing Section 504 both substantively and procedurally. Substantively, the statute requires that DOT's new regulation include "minimum criteria for the provision of transportation services" to handicapped persons. Procedurally, the statute calls for explicit regulatory provisions concerning the participation of handicapped persons in the establishment of transportation services for their use and for monitoring by the Department of recipients' compliance with section 504 requirements.[7]

In line with this directive, the Department of Transportation issued the aforementioned proposed final rules on September 8, 1983. At this writing, these rules are still in the Department's review process and are not expected to be finalized until early 1985.

The proposed rules preserve the local option concept in that eligibility may be established by making fifty percent of a recipient's peak and non-peak fixed route bus fleet accessible to "handicapped and elderly persons"; by providing paratransit services for the elderly and the handicapped; or by providing some mix of accessible fixed route service and paratransit services.[8]

If paratransit (also termed special services in the proposed rules) is provided, then it must meet certain criteria specified in the proposed rules. These criteria[9] can be summarized as follows:

- service area must be the same as that of the recipient's general public service;
- the paratransit service must be available on the same days and for the same hours as the recipient's general public service;
- the cost of a trip to the user must be comparable to that charged for a similar trip made by the general public;
- trip priorities or trip purpose restrictions can not be imposed;
- wait time for special service must be reasonable, and,
- no waiting lists can be maintained, i.e., service must be available for all eligible persons.

These criteria are viewed as minimum standards to be met by all recipients of federal transit assistance funds. However, in meeting these criteria no recipient will be required to expend, in any fiscal year, more than:

Alternative 1 - 7.1 percent of the average annual amount of Federal financial assistance for mass transportation it expects to receive over the current fiscal year and has received over the two previous fiscal years

or

Alternative 2 - 3.0 percent of the average of the recipient's operating budgets for the current fiscal year and the previous two fiscal years.[10]

The proposed rules continue by specifying allowable costs which may be counted towards the above financial effort ceilings.

Finally, the proposal specifies various procedural requirements which recipients must follow. These requirements cover the recipient from the first step of obtaining public comment upon the recipient's proposed program for fulfulling these proposed 504 rules to the final certification of the program by the UMTA Administrator.[11]

The service criteria, including the limitations on recipient expenditures, and the procedural requirements represent the Department's response to the requirements of Section 317(c) of the Surface Transportation Assistance Act of 1982. The public response to the publication of the proposed rules was quite sizable and the Department extended the original comment period to accommodate this high level of public interest.

While the exact form of the final rules is unknown at this writing and, thus, impact projections must, by their nature, be somewhat speculative, the proposed rules can not be assessed without an effort at impact projection. The following sections present information describing the impacts anticipated by ten publicly funded transit systems from the proposed final rules for the implementation of Section 504 of the Rehabilitation Act of 1973.

Impact Projections

In order to access the potential impacts of the proposed Section 504 regulations, case studies were conducted of nine public transit systems providing specialized and fixed route transit services and one private-non-profit provider of specialized services which receives UMTA Section 5 funds via a local public body.* The private-non-profit provider is located in a community with a privately owned fixed route transit system which does not own any accessible vehicles.

These systems have been studied previously** with respect to their financial and service chracteristics. Thus, having considerable background information for these systems, they were selected for the present study.

The impact analysis is undertaken in a two phase manner. First, the respondent's self-reported views of the potential impacts of the proposed regulations are reported. Second, data describing the present service attributes of the systems are presented and analyzed in light of the proposed regulations' service criteria. Interestingly, the two approaches do not necessarily yield the same conclusions for all systems.

Respondent Reported Impacts. Table 2 presents the respondent reported impacts and related comments, if any. As the table reveals,

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* Colorado Springs Transit, Colorado Springs, Colorado; Corpus Christi Transit Authority, Corpus Christi, Texas; Greensboro Agency Transportation Express (GATE), Greensboro, North Carolina; Peninsula Transit (PENTRAN), Hampton/Newport News, Virginia; MAT'S Mobilization for Special Customers (MOBY), Omaha, Nebraska; Neighborhood Dial-A-Ride, Orange County Transit District (OCTD), Orange County, California; TRI-MET, Portland, Oregon; Dial-A-Ride Transit (DART), St. Petersburg, Florida (on October 1, 1984, DART became part of the Pinellas Suncoast Transit Authority); METRO, Seattle, Washington; and Metropolitan Tulsa Transit Authority, Tulsa, Oklahoma.

**"The Future of Specialized Transportation Services in an Era of Public Financial Austerity: A Review of Selected Systems," Lalita Sen, Erskine S. Walther and Harold G. Willis, Ninth National Conference on Specialized Transportation, Sarasota, Florida, October, 1983.

TABLE 2: RESPONDENT REPORTED PROJECTED IMPACTS OF PROPOSED SECTION 504 REGULATIONS

System	Impacts Reported
Colorado Springs Transit Colorado Springs, Colorado	Fulfills the proposed requirements based upon its 50%+ accessible fixed route service.
Corpus Christi Transit Authority Corpus Christi, Texas	Specialized service believed to be in compliance at the present time.
Greensboro Agency Transportation Express (GATE) Greensboro, North Carolina	The proposed regulations would "put the system out-of-business."
Peninsular Transit (PENTRAN) Handi-Ride Hampton-Newport News, Virginia	No expected problems, currently changing service to bring it into line with the proposed regulations with the exception of the advanced reservation requirement which believes can be justified based on the geographic scope of the service area.
Omaha Transit Authority (MOBY) Omaha, Nebraska	Specialized service believed to currently exceed the proposed requirements; with exception of advanced reservation, can eliminate advanced reservation but would reduce efficiency and require additional vehicles.
Orange County Transit District (OCTD) Neighborhood Dial-A-Ride Orange County, California	Fulfills the proposed requirements based upon its 50%+ accessible fixed route service.
TRI-MET Portland, Oregon	Specialized service currently under review with respect to changes needed to meet proposed requirement. If must end advance reservation then anticipate a reduction in system efficiency and in the number of trips provided.
Dial-A-Ride Transit (DART) St. Petersburg, Florida (Pinellas Suncoast Transit Authority, Clearwater, Florida)	System merged with county-wide system on October 1, 1984, the unified system meets or exceeds requirements.
Seattle METRO Seattle, Washington	Fulfills the proposed requirements based upon its 50%+ accessible fixed route service.
Metropolitan Tulsa Transit Authority Tulsa, Oklahoma	No major impacts expected, only difficulty is the present advance reservation requirement which can be shortened.

only two systems (GATE and TRI-MET) are anticipating any difficulties if the proposed requirements become the final regulations. GATE reports that it would be "out-of-business" while TRI-MET reports a probable decrease in system efficiency and a reduction in the number of trips provided. TRI-MET is currently reviewing the changes necessary to bring the paratransit system into compliance and the associated topic of increasing the accessibility of the fixed route bus system (the light rail system will be fully accessible). For TRI-MET, the primary source of difficulty would be the elimination of the advanced reservation requirement. The advanced reservation provision in the proposed regulations is also a source of difficulty for the GATE system.

Four of the systems examined can fulfill the proposed requirements by means of their existing fixed route systems which meet or exceed the 50% accessibility standard (Colorado Springs, Orange County, Pinellas County, Seattle). While these systems fund, and will continue to fund, specialized paratransit programs, the specialized programs can be viewed as supplemental services. As such, they would not be required to meet the proposed service criteria for paratransit services; at least, that is the dominate view at this point in time.

Of the remaining four systems, all believe that they are substantially in compliance now and that moving to full compliance would present relatively few problems, if any. Of these systems, one (PENTRAN) is in the process of altering its paratransit service to meet the proposed service criteria. The proposed elimination of advance reservation requirements is the one criterion which most of these systems indicated would present difficulties.

Thus, of the ten systems examined, six offer specialized transportation programs which would have to comply with the proposed regulations. While two systems reported varying degrees of difficulty in complying, the remaining systems reported few anticipated difficulties should the proposed regulations become the final regulations.

Analysis of Existing Services. The existing service characteristics of the six systems whose specialized services would have to comply with the final Section 504 regulations are displayed in Table 3. Data on service hours, advanced reservations requirements, trip prioritization, accessible fixed route service and service area are shown for each system.

As can be seen, all six systems are presently in non-compliance on at least one of the service requirements contained in the proposed rules. Needless to say, some systems are closer to compliance than are others.[12]

The primary area of difficulty is the advance reservation requirement imposed by all of the systems shown in Table 3. None of the systems reported an availability of sufficient vehicles to provide on-call service, the availability of sufficient capital funds to purchase additional vehicles or of sufficient operating funds to operate additional vehicles if they could be purchased. However, to be fair, with the exceptions of GATE, TRI-MET and Omaha, none of the systems indicated that they had even considered this implication of the removal of the advanced reservation requirements.

TABLE 3: CHARACTERISTICS OF EXISTING SERVICES*

System	Advance Reservation	Service Hours	Prioritize Trips	Service Area	Accessible Fixed Route
Corpus Christi Transit Authority Corpus Christi, Texas	Yes, 24-hours	7:30 am-6:00 pm M - F AFDC - 24 hours (medical only)	Yes	Same as fixed route service	None
Greensboro Agency Transportation Express (GATE) Greensboro, North Carolina	Yes, 24-hours	8 am - 5 pm M - F	Yes	Larger (privately owned transit not connected with GATE)	None (privately owned transit not connected with GATE)
Peninsula Transit (PENTRAN) Handi-Ride Hampton-Newport News, Virginia	Yes, by 2 pm previous day for Handi-Ride, by 4pm previous day for taxis.	6 am - 6 pm M - Sat. Taxi in evenings (no Sunday service)	No	Same as fixed route service	Less than 50%
Omaha Transit Authority (MOBY) Omaha, Nebraska	Yes, 48 hours	6 am - 9 pm Taxis after 9 pm	No, by trip type Yes, by destination	Same as fixed route service	Less than 50%
Tri-Met Portland, Oregon	Yes, 48 - hours	7 am - 6 pm M - F	Yes	Same as fixed route service	Less than 50%
Tulsa Transit Authority Tulsa, Oklahoma	Yes, 3 working days	6 am - 6 pm M - F Taxis for evenings and weekend	No	Same as fixed route service	None

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*The four systems (Colorado Springs, Orange County, Pinellas County and Seattle) which could quality based upon their accessible fixed route service are omitted from this table.

With respect to hours of service, most systems provide fewer hours of operation for the specialized service than for the conventional fixed route transit service. However, two systems (PENTRAN and Tulsa) have arrangements with taxi companies to provide service when the system's own vehicles are not operating, mostly evenings and weekends. Such arrangements can result in longer hours of operation for the specialized service than for the conventional service. The difficulty with utilizing taxi companies to expand hours of operation is the availability of accessible service from taxi companies.

Trip prioritization is another area where most of the systems examined would be required to alter present practices. Most systems prioritize trips in order to allocate their relatively limited transportation resources to trips of greatest need, e.g., medical and work. Other systems use this approach as a method to avoid duplicating transportation services offered by other transportation providers, e.g., exclusion of social service agency trips.

The removal of trip prioritization seems to indicate the need for additional vehicles if the same level of service is to be provided for what are now the top priority trips. Only one of the systems examined (TRI-MET), reported having evaluated the impact of this change upon their current service.

With respect to service area, four of the systems examined operate their specialized services over the same geographic area as their conventional transit service. One system (GATE) operates over a larger area than the private fixed route system.

This analysis presents a somewhat different picture of the potential impacts of the proposed Section 504 regulations than emerges from the self-reported view of the potential impacts. However, there may, in fact, be no conflict between the conclusions of the two tracks of analysis.

This analysis suggests that most of the systems examined would be required to make, apparently, major changes in their current operations if the proposed regulations become the final regulations. The systems may have found relatively easy methods of bring existing service into line with the proposed regulations. In such a case, the respondent reported views of little difficulty, in the main, in meeting the proposed rules would be correct as would the areas of change identified by the second phase of the analysis.

What is troublesome are the general indications that many respondents are not familiar with the details of the proposed regulations. It will be recalled that some of the systems indicated that existing services fulfill the proposed requirements. While the second phase of the analysis indicated that several areas of potentially important change would be required before any of the systems studied would be in compliance with the proposed regulations.

Several systems indicated that they were already spending the amount of funds which the proposed regulations would require, if not more. It may well be the case, that the percentage expenditure requirements proposed are being viewed as the primary measure of compliance. And, hence, the judgement that the system is already in compliance. While this would represent a misreading of the proposed regulations, it would be a rather understandable error. For, as the review of past Section 504 regulations indicates, the primary or only measure of compliance has often been the expenditure of a pre-set percentage of funds on specialized transportation services. The proposed regulations differ, notably, in that particular service criteria would be mandated with the expenditure percentages representing maximum levels of effort rather than the minimum levels, as in the past. It may well be that UMTA has failed to make this aspect of the proposed change in policy clear, especially to smaller systems who, generally, lack the specialized staffs found at larger systems.

Concluding Comments

The history of federal guidelines for the transportation of the elderly and the handicapped seem to have come full circle. Original federal directives embraced the concept of special efforts with local areas making the service delivery decisions. The proposed regulations again advance the concept of local option with an evolved form of special efforts. The proposed regulations go beyond the starting point of this cycle by detailing specific service provision criteria which must be fulfilled.

During the intervening years, the views and positions of the various communities of interest participating in the Section 504 debates have undergone various degrees of modification. The experiences of numerous transit systems and specialized service providers have provided cost, reliability and utilization data which have helped to define the real world impacts of the various approaches to ensuring the mobility of elderly and handicapped citizens.

Even so, the major points of view remain, largerly, the same as in the early 1970's: mainlining vs. specialized service. Representatives of the handicapped communities argued forcefully for mainlining (accessible fixed route transit) more as a force for social change than as an efficient means of transportation. Supporters of specialized services approached the issue from a quality and efficiency of transportation perspective.

Over the past decade, the need for mainlining for social goals has declined as handicapped citizens have become more accepted in mainstream America, but the support for mainlining in public transportation does not seem to have diminished significantly among representatives of the handicapped communities. The experiences of numerous transit systems seem to indicate that accessible fixed route transit meets the needs of only a minority of handicapped citizens, while specialized services can provide a better quality of transportation service for a wide range of elderly and handicapped individuals. It would appear that the time is correct for the formulation of a consensus view which supports a combination of accessible fixed route service for those segments of the handicapped community for which this is a valuable service and specialized transit for those whose needs are not met by accessible fixed route services. The return of federal policy to the local option arena may be a recognition of this need for local consensus formulation.

Whether or not such is the case, it is clear that the forum of interest is shifting from that of federal regulations to that of local decision making. The questions which will be posed in these local actions should be of great interest to the public at large as well as to the elderly and the handicapped communities. In an era of declining or static financial resources coupled with increasing needs, the choices faced by local transportation providers and local political decision makers are likely to be ones of great difficulty and considerable delicacy.

Notes and References

[1] Rosenbloom, Sandra. "Federal Policies to Increase the Mobility of the Elderly and the Handicapped," Journal of the American Planning Association, Vol. 48, No. 3, p. 338.

[2] *Ibid.*

[3] *Ibid.* and 49 CFR Part 609.15, amended.

[4] *Ibid.*

[5] Paratransit Services for the Transportation Handicapped, Urban Mass Transportation Administration, U.S. Department of Transportation, Washington, DC, Final Report, April 1982, p. 58.

[6] Federal Register, Vol. 44, No. 106, Thursday, May 31, 1979, pp. 31455-31457 and 31459-31463.

[7] Federal Register, Vol. 48, No. 175, Thursday, September 8, 1983, p. 40685.

[8] *Ibid.*, p. 40693.

[9] *Ibid.*

[10] *Ibid.*

[11] *Ibid.* pp. 40693-40694.

[12] At this point it should be noted that the GATE system is in an unusual position in that it is not associated with a publicly owned fixed route transit system and operates in a community without a publicly owned transit system. Thus, it is not clear that the proposed regulations would apply to the GATE system. If they would apply, the base for judging compliance is not known. If the proposed regulations do apply and the existing GATE service is used as the base for judgement, then the only proposed service criterion which would require a change in existing services is the elimination of advanced reservation requirements. The impacts such a change would have upon the GATE system is the basis for the system's self-reported impact of being put "out-of-business" by the proposed regulation.

THIRD INTERNATIONAL CONFERENCE ON MOBILITY AND TRANSPORT OF ELDERLY AND HANDICAPPED PERSONS

ORLANDO, FLORIDA, OCTOBER 29th, 30th, 31th, 1984

"EFFECTIVE TAXICAB TRANSPORTATION FOR THE DISABLED"

BY

MICHEL WILSON
ADMINISTRATIVE DIRECTOR
TRANSPORT ADAPTE DU QUEBEC METRO INC.
(QUEBEC, CANADA)

INTRODUCTION

In January 1982, TRANSPORT ADAPTE DU QUEBEC METRO INC., a specialized transport service and a subsidiary of the Quebec City Transit Commission, introduced the use of taxicabs for transportation of disabled persons throughout its area. This new measure brought drastic changes in the operation of the system; the results are most positive for the Corporation, its users and the taxicab industry. A majority of the Corporation's clientele, such as the blind, mentally deficient and the handicapped in manual wheelchairs, are now transported by cab. In addition, adapted vehicles with ramps are used almost exclusively to transport users of motorized wheelchairs.

In December 1983, a total of 860 persons were admitted to the service. Out of the total trips made in 1983, 37% were by ambulatory disabled; 56% were by wheelchairbound and 7% represented attendants. The trip destinations were as follows: 32.3% for work, 33.6% for leisure, 25.5% for services and 8.6% for studies; 62% of the users were transported by taxis and 38% by modified vans.

The integration of taxicabs with our pre-existing resources was easily done. We have targeted the Cooperatives of the Quebec City area, first because they represent the greater number of cars in their own district; secondly, they are structured with a board of Directors, a supervisory Committee and a code of ethics. Thirdly, the drivers, being the owners of their cars, have committed themselves to respecting the rules of their Cooperative and therefore, do not tend to be unionized.

Presently, we are dealing with four different Cooperatives; each of them serving its own sector of the Quebec City area.

RESERVATION PROCEDURE

The reservation procedure did not change for the user. It is rather in the internal operation that some modifications were undertaken.

The reservation is taken on the telephone by an operator who checks with the central file to find out which mode of transportation was assigned to the user when he or she was admitted. Having established, for instance, that the trip can be made by cab, the operator will then forward the request to the dispatcher on duty. According to the address and hour requested, the dispatcher will check the feasibility of combining more than one trip request for use of the same taxi. This means that one car may take up to three or four passengers with different addresses, all on the same run. On the other hand, considering the addresses to be served from a geographical point of view, the dispatcher could require more than one cab for a group of persons, if it is previously established that the total ride cost will be lower by using more than one car.

The dispatcher will then call the taxi Cooperative covering the territory from which the trip request originated. The taxi dispatch will transmit the call to the cab drivers, informing them of the number of persons to be carried, attendants to be accepted or wheelchair transported.

For regular and repeated trips, the taxi dispatcher is supplied in advance with the list of users, addresses to serve and the pick up time requested. All orders given to the taxi dispatch bear an order number which appears on the bi-monthly billing. This billing also includes all the signed charge slips presented by the drivers.

ADVANTAGES AND INCONVENIENCES OF THE SYSTEM

In looking at the advantages and inconveniences which characterize this new orientation of the taxicab industry, first the advantages are cited:

1.- We have increased our trip resources over the past two and a half years without having to buy additional adapted vehicles. Therefore, investment on that account is considerably slowed down. As of August 1984, we have a fleet of six modified vans in comparison to the eleven in 1981.

2.- Transportation impossibilities (10 % in 1981) were brought down to almost none for 1982 and 1983. This statistic could change in the future.

3.- Transportation cost per passenger is considerably reduced (cfd. statistics).

4.- There are less changes of hours imposed on the user.

5.- The passenger's average travel time is considerably shortened, to the satisfaction of the users.

6.- It is an ideal mode to integrate with the typical transportation system.

7.- Users can travel more easily and flexibly from one place to another.

8.- Due to the increased number of vehicles available, the dispatchers experience a greater flexibility in assigning trips.

9.- The twenty-four hours reservation requirement has been reduced to eight hours.

For the last three years, the number of employees in our Corporation has not increased. The thirty-four employees in 1981 have by August 1984, been reduced to twenty-three. This suggests that the existing staff can absorb some increased demand without affecting the service.

11.- Finally, one cannot ignore the new source of income brought to the taxi industry which now transports 2/3 of our clientele.

Turning to the inconveniences experienced by the service users suggests the following negatives:

1.- Premature wear or occasional damages to the wheelchairs due to multiple manipulations.

2.- Wheelchairs are often cold, wet or both, depending on the weather. This is related to the fact that with certain types of cars, the trunk lid cannot be closed properly when there is one or two wheelchairs in it.

3.- The physical effort required to transfer oneself from the wheelchair to the car and vice-versa, is substantial.

Our Corporation, for its part, after three years of experience, has noticed the following problems:

1.- The fleet of taxis in our area is made up increasingly of small cars. This increases the difficulty of carrying more than one passenger, especially when wheelchairs are involved.

2.- On peak hours or in bad weather, it is more difficult to obtain taxis to satisfy the scheduled users.

3.- Passengers experience delays frequently due to the fact that cab drivers can choose their trips.

4.- Since transportation is easily available to the disabled, some users have contributed to the increase of "no-shows". A "no-show" is a transportation demand for which the user is not present, as scheduled, at a given address. To keep that problem to a minimum, the user is advised by letter that if the situation is a recurring one, a more stringent reservation procedure would be applied in his case.

Despite these problems, the advantages outweight the negatives and inconveniences. As a consequence, the Corporation has agreements with all four local Cooperatives for the next two years.

Main terms of the agreement

- The Corporation (TAQM) is not liable for any trip which has not been expressely requested and confirmed with an order number;
- TAQM is not responsible for any expenses occured when a user is not present at a given address (no-show);
- The Cooperative must inform TAQM if an unexpected or alternate user or attendant shows up for the trip at a given address;
- The cab driver must provide proper assistance to the user to and from the car;
- The meter is to be started only when the user is on board and must be stopped at the arrival point;
- The Cooperative must show proof to TAQM that a minimum liability insurance of, at least, $500 000., has been contracted to cover the disabled person when outside the car;

- TAQM is not liable for any additional charge covering handling of luggage or parcels;

- TAQM pays a 5% administrative charge on the total billing for credit support;

- The Cooperative supplies a list of prices for standard trips agreed upon by both parties;

- TAQM can require that a cab driver, who has not complied with the basic obligations of the agreement, be removed from the list of approved drivers.

Finally, a few statistics that will confirm the positive results of the last three years.

Statistics

- 2/3 of the users have been transported by taxis and 1/3 used the modified vehicles of the Corporation;

- The average trip distance represented 10 kilometers (one trip can include one or more addresses to be served);

  The average distance covered by a single user was 6,3 kilometers;

- The average number of passengers per ride is 1,7 for the whole territory (this statistic may vary according to each Cooperative's area).

  N.B. Use of a "passenger/ride" ratio, rather than a "passenger/hour" ratio, is because of the difficulty in calculating the actual time that the taxi was in direct service for TAQM.

Summarily, in 1981, for a total operating cost of $927,341., 51 544 people were transported for an average cost of $18. per person. At that time, only adapted vehicles were used. The impossibilities represented about 10% of the total demand. In 1982, some 65,982 persons were transported (28% more than in 1981). Total spending for that year represented $1,157,385. The average cost per person transported in an adapted vehicle was $22.14 compared to $15.18 by taxis. Combined average cost per person was $17.54 in 1982. In 1983, 79,714 persons (21% more than in 1982) were transported for a total operating cost of $1,137,824. Combined average cost per passenger was $14.27. The average cost per person carried in an adapted vehicle was $17.91 while the taxi cost was $12.22.

For 1984, we anticipate ending the year with a 15% increase in the number of persons transported. The approved budget is $1,225,298.

CONCLUSION

It can be said that giant steps have been made to improve public transportation for the disabled in the Quebec City area. The use of taxis proved to be a new and flexible mode of transportation which has permitted the demand for specialized transport to be met more adequately than ever. The users' satisfaction is one's proof of this claim. The taxicab is now an integrated and important part of the public transportation system for the disabled.

TRANSIT TO DISADVANTAGED: CASE STUDIES, A MODEL FOR IMPROVEMENT

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INTRODUCTION

It has been said that transportation is the life blood of an area's economy. Also of considerable importance is the fact that transit for the transportation disadvantaged is an essential element for a more productive, healthier, and happier life for this important group of our citizenry.

Mississippi has an abundance of transportation disadvantaged and limited financial resources for adequately meeting those needs. The area is a poor, sparsely populated rural state with a total of about 2.5 million people. According to the 1980 U.S. Census, Mississippi leads the nation in poverty with 24% of the State's population in this category compared to 12.5% nationally. Mississippi ranks 49th in median income with $14,992 compared to the national average of $19,908. The State's total operating budget for Fiscal Year 1985 (July 1, 1984-June 30, 1985) is approximately 1.36 billion dollars. Approximately 70 percent of the operating revenues is derived from state sales and income tax. The task of meeting the rather substantial disadvantaged transit needs under existing and anticipated funding constraints is an overwhelming one.

The purpose of this paper is to document the approach taken by the Mississippi Department of Energy and Transportation and more importantly, the efforts of the local transit providers to make the most of limited funds through improved coordination, and effective and efficient use of resources locally.

PROBLEMS

The Surface Transportation Assistance Act of 1978 amended the Urban Mass Transportation Act of 1964 to include "Section 18 - Public Transportation for Non-Urbanized Areas". The Section 18 Program was designed by the U.S. Congress to improve and augment general public transportation in rural areas and cities with fewer than 50,000 people.

In 1980 the Governor of Mississippi designated the newly formed Mississippi Department of Energy and Transportation to administer the Section 18 Rural Public Transportation Program. It didn't take long to discover that a myraid of problems existed regarding the provision of transit services to the transportation disadvantaged of rural Mississippi. In fact today all of the problems have not been solved and service is not at an optimum level. However, it is believed that most of the problems have been identified, many have been solved, and the remaining problems are being addressed. More public transit is available in Mississippi than ever before. On the other hand, unfortunately there are more transportation disadvantaged in the state than ever before.

The first major problem observed with rural transit in Mississippi was the extent of deficiencies in existing services. Due to limited income, age and physical disability the size of the transportation disadvantaged population in the state was tremendous.

A number of federal programs had been developed over the years to address the needs of the transportation disadvantaged, but they were neither developed nor administered in any kind of coordinated manner to collectively utilize available resources in maximizing available transit services. The Urban Mass Transit Administration's Section 16(b) (2) was designed to meet the special needs of older people and the handicapped by providing funds to acquire vehicles and other equipment. The Social Security Act Title XX Program, Title III of the Older Americans Act, and the Community Services Act of 1974 also made funds available to assist in the provision of transportation services for eligible segments of the transportation disadvantaged population. The services provided through the use of funds from the previously mentioned programs were of an exclusionary nature. These transportation services have, however, been a vital part of providing essential service, mainly to elderly and handicapped and low income persons. In some cases, the transportation is needed simply to make other program benefits accessible (i.e. headstart, medical, nutrition), while in other cases the transportation service improves the individual's quality of life by providing access to employment, shopping, and recreation for example. Due mainly to confining federal regulations and different organizational goals and policies, there has been a proliferation of transit providers throughout the state.

The evolution of transit in Mississippi has resulted in 800 vehicles providing service under the direction of 150 separate organizations. Due to the exclusionary nature of much of the service and limited coordination among providers, the cost per unit of service is high. To further complicate the situation, many of the agencies providing service experienced a reduction in funding or inadequate increases in terms of increased cost of providing services. Such circumstances have led to poor vehicle utilization and limited transportation service. Additional problems associated with the fragmented, poorly funded, exclusionary service approach to transit have included: excessive administrative costs, high maintenance cost with essentially no preventative maintenance, limited accountability, poor vehicle design, i.e.

not very accessible to elderly and handicapped due to narrow isles, limited room between seats, high steps, limited capacity and limited useful life; inconsistent and frequently inadequate levels of safety, i.e. limited or no driver training, emergency medical training, defensive driving, commercial licensing or transit driver certification; and poor public image.

Funding for most of the services has historically been total federal or a combination of federal and local dollars. Many of the previously mentioned problems are perpetrated by funding source restrictions and the fact that transportation is not the principal function of the provider organizations. Limited local level flexibility exists for the use of funds. When opportunities have been identified to improve coordination or to consolidate the provision of service turfism becomes a key issue.

It has been well documented that most social service agencies will resist the consolidation, or even the coordinated dispatching of the vehicles which serve their clients. The plea is that they cannot carry out their programs effectively unless they directly control client transportation service. Also, claims are made that coordination would cause a compromise of service to their clients. The problem to be addressed is why a professional, social or medical worker wants to be a transit operator, and why the taxpayer should support these individual vehicle fleets if it can be shown that consolidation or coordination can produce better service at the same or less cost.

State level reluctance to pool financial resources is frequently stated to be because another agency is not capable of being compassionate enough or interested enough in an agency's clients to assume transportation responsibilities satisfactorily. This is often the only reason provided publicly. Under the institutional arrangement for provision of transit services, in recent years, there has been a limited and totally inadequate level of monitoring activity based on performance or service standards and various indicators of efficiency and effectiveness. The result has been a tremendous variation from one area to another in terms of level of service and cost/unit service. It is not difficult under the circumstances to see why transportation for the disadvantaged is frequently perceived as a poorly conceived inefficient government giveaway program rather than an essential public service in some ways similar to parks, libraries, and fire-police protection.

In addition to inadequate monitoring, the transit services are poorly planned, if planned at all. Frequently the level of participation in the service planning process has been limited for user groups, local government officials, members of the general public and other transit providers. Without the necessary broad based participation in the service planning phase, needs cannot be adequately determined, existing service levels cannot be determined, and the best alternatives cannot be designed and evaluated.

Once services are provided, the availability of those services is a well kept secret due to limited publicity. Other problems include: a limited level of technical assistance available to the providers from the state or federal level; inadequate insurance coverage and excessive rates; and, the absence of any kind of forum for the variety of transportation providers to assemble, identify, and address issues of common interest and to collectively recommend policies, programs, and solutions to problems to appropriate federal and state legislative groups and agencies in addition to simply sharing experiences, ideas, and improving coordination.

SOLUTIONS

Many of the previously mentioned problems were identified during the course of preparing a statewide transit plan upon being assigned responsibility for rural public transit administration. The planning effort in itself was a first major step toward improving transit in Mississippi. The study was conducted by the state's ten planning and development districts following guidelines established by the Department of Energy and Transportation to ensure consistency. For the first time the state understood what types of services were being provided at what cost, the level of transit demand, deficiencies in service, and alternative means of addressing those needs that were not being met. The planning process required a series of county level public meetings. A sincere and successful effort was made to include transit users, potential transit users, transportation disadvantaged, elected officials, transit providers, and representatives of other segments of each area's population. The plan continues to serve as a general (as opposed to rigid) guide for implementing coordinated transit throughout the state.

Meeting unmet trip demand from the transportation disadvantage will require a combination of more efficient and effective utilization of existing resources and new resources as well. The optimum means of improving coordination to enhance efficiency is often consolidation of transit service responsibility. Pooling the financial resources increases the potential for flexibility in providing expanded nonexclusionary services in a comprehensive manner without duplicate administrative costs. Social service agencies that entered the transportation business out of necessity to get their clients to service centers, in many cases, would do well to purchase those services from a consolidated provider of transportation services. The social service agency would then be free to emphasize the provision of its principle services. It is readily acknowledged that a consolidated area provider may be a human service agency with responsibilities other than transportation. Consolidation of transit service responsibility will, more or less, often enable the agency to justify, on an economic basis, hiring mechanics for preventative maintenance and repairs which may increase useful life of vehicles and safety, and bulk purchase and storage of fuel.

The Section 18 Rural Public Transit Program serves as a catalyst for consolidating services where consolidation is determined to be beneficial. The program also ensures an increase in state level transit activity which creates an opportunity for expanded transit technical assistance to providers and potential providers. The Department of Energy and Transportation employs a Transit Manager and three transit specialists who work with transit providers to maximize service to the public and minimize the cost per unit of service through a variety of measures including consolidation or improved coordination, increasing contract revenue for primary service providers, planning, and operational improvements. The Department also serves as a transit advocate with the state legislature and U.S. Congress.

Reluctance to consolidate services is difficult to overcome in many cases. Assurances must be provided to an agency that its clients will receive at least the same level of transit service at no cost to the agency in excess of what they are currently spending. It is usually not enough, however, to demonstrate equal service for equal cost to the agency. An increase in service and/or a reduction in cost plus a plan or agreement to transfer drivers or other employees to the primary transit provider is frequently required before an agreement to consolidate can be consummated. State level attempts to consolidate administrative responsibility in order to streamline and standardize reporting and increase provider accountability require the same kind of approach outlined for local providers. The standardized reporting facilitates the collective documentation of transit efficiency and effectiveness necessary when attempting to secure additional financial support. Safety and operational standards can also be established and monitored using the report data thereby increasing the level of accountability and ensuring the best use of limited resources.

The perception of transit in rural areas or transit that targets the disadvantaged as an inefficient government giveaway is not easy to overcome in some areas of the country. If the system is open to the public it may be best to standardize logos using the word public, i.e. MISS PUBLIC TRANSIT Provided by: (local agency). Standardizing vehicle colors will also make them easily recognizable. Prolific local media coverage and a well executed advertising and promotional program will also help change the negative perception and pay dividends in increased general public ridership and revenues. More people using the system and lower subsidy per passenger trip will translate into more political support for the system. Although numerous concepts, techniques, and approaches to transit have been developed and used around the world and we can all obviously benefit from such knowledge, it has been our experience that local leadership, local flexibility, and local innovation are the real keys to successful transit for the disadvantaged in Mississippi.

EXAMPLES OF LOCAL DIVERSITY AND INNOVATION

One important conclusion we reached upon completing an evaluation of Mississippi's transit systems was that no standard model could be developed from empirical observations to ensure the success of a transit system. The number of significant variables that must be taken into account dictate diversity and innovation for success. Local politics, availability of financial resources, socio-economic characteristics, institutional characteristics, transportation needs, local leadership and physical characteristics of an area are among characteristics affecting the design of an effective and efficient transit system. The following transit projects were influenced by different local environments, but do have some things in common consistent with state guidelines. All three projects provide services to the general public and generate as much revenue as possible to offset the cost of services while at the same time emphasizing service to a particular target group or several target groups. All three projects are committed to providing an essential community service and finally, all three incorporate preventative maintenance, driver training, and close monitoring of operational cost in order to maximize system efficiency.

Mississippi Valley State University (MVSU)

Mississippi Valley State University is a coeducational school situated in what is traditionally defined as the Mississippi Delta: an area of agriculture concentration. The University transit service area is composed of nine counties (Figure 1).

Since 1958 the school has provided limited transportation for students and employees. In 1982 M.V.S.U. became a Section 18 Rural Public Transit Project and has continued serving students and employees, with improved services, as its target clients. The University, of course, made a commitment to community service providing transit to the general public including the transportation of disadvantaged.

Administration of the program is beyond the traditional approach in that such administration is under the auspices of the Continuing Education Program of the University. Direct supervision and internal project evaluation is provided by the Assistant Director who reports to the Director of Continuing Education, who is responsible to the University President.

The project offers a pass book discount to University and general public riders. Fixed-route, fixed-schedule services are provided between residential areas in the region and the University in the mornings and between the University and residential areas in the region in the afternoons. The route structure is designed to provide service for mental health center clients and other social service recipients.

The system is operated in an exceptionally professional manner benefiting the nine county service area and the University as well. There is a shortage of student housing on the University campus. The transit system makes the University more accessible to potential students in the region and according

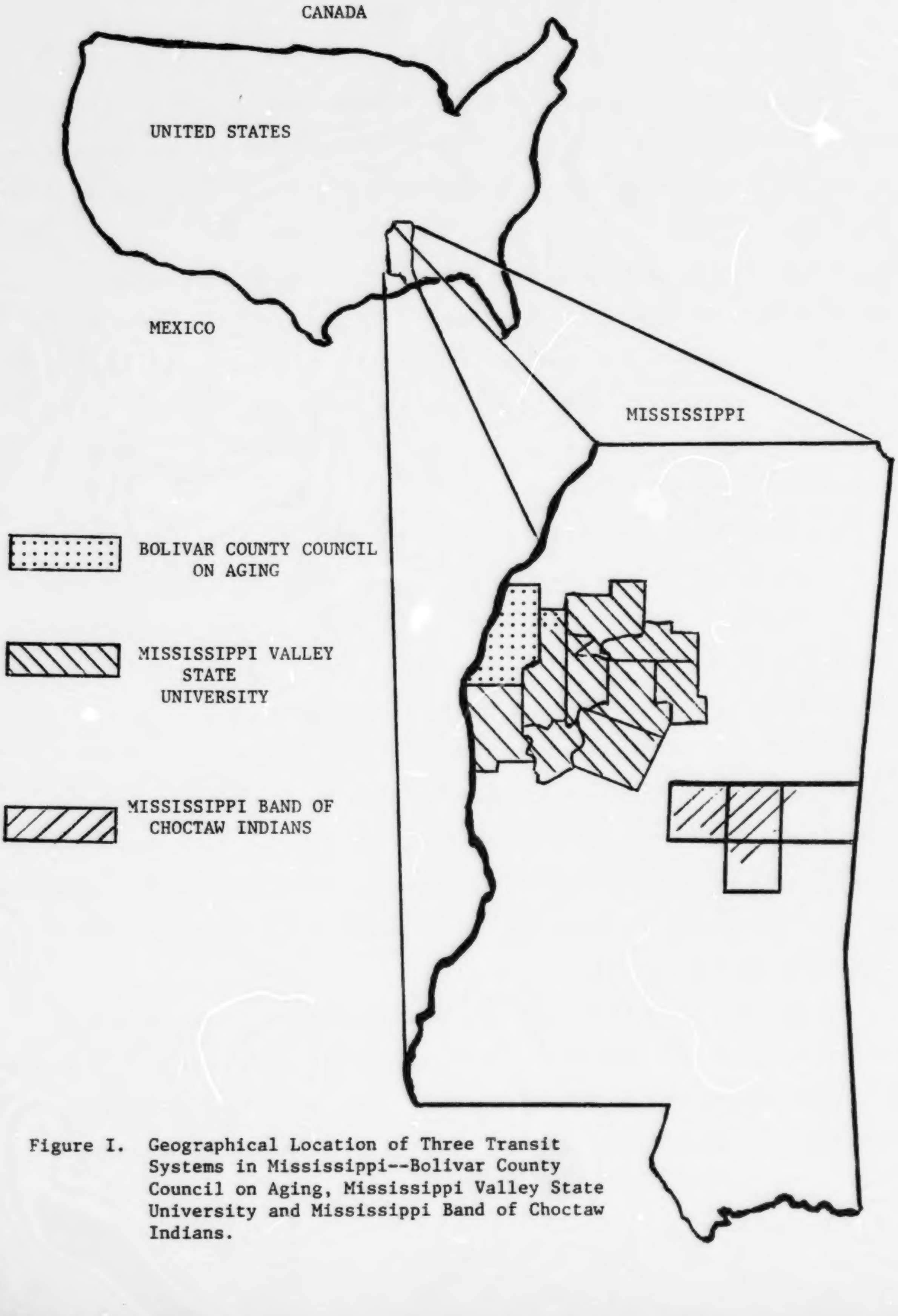
CANADA
UNITED STATES
MEXICO
MISSISSIPPI
BOLIVAR COUNTY COUNCIL ON AGING
MISSISSIPPI VALLEY STATE UNIVERSITY
MISSISSIPPI BAND OF CHOCTAW INDIANS

Figure I. Geographical Location of Three Transit Systems in Mississippi--Bolivar County Council on Aging, Mississippi Valley State University and Mississippi Band of Choctaw Indians.

to University officials is likely responsible for some of the increased enrollment experienced each year since the service began. The services are also an attractive amenity for University employees and the school's image is enhanced due to the services provided to the general public and transportation disadvantaged in the area. Additional service is made available to the state prison in the same manner that the Bolivar County Council on Aging has used.

Forty three percent of the project's operating costs are paid by contract and fare revenues and an average of 8,334 passenger trips are served each month.[1]

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[1] Average Recovery Cost Ratio, January, 1984, through June, 1984.

Bolivar County Council on Aging (BCCOA)

The B.C.C.O.A. is a social service agency providing the majority of its services in Bolivar County, a predominantly rural county in the Mississippi Delta area (Figure 1). The agency has provided some transportation services to the poor, elderly, and handicapped since 1975. Since becoming a Section 18 Rural Public Transit Project in 1981 the B.C.C.O.A. has continued to target its service toward the elderly and handicapped. The project provides regularly scheduled service to welfare offices, shopping centers, health care and medical facilities, utility offices, meal sites and special social activities. In addition, however, the agency now provides service to the general public. The expanded services are publicized and promoted, thereby enhancing the agency's image in the community. The revenues generated from serving general public needs (mainly work trips) make it possible to provide a better level of service to the transportation disadvantaged.

Through creative and innovative management the project has generated substantial contract revenues. Much of this revenue is a result of providing service to employees of the state prison in the area three times a day at $45 per month and Sunday service in the prison compound to prison visitors at $1.00 per person. Revenues more than offset the cost of providing services enabling the project to provide more service to the transportation disadvantaged and enhancing its image which facilitates efforts to get increased funding from local government when necessary.

Fifty nine percent of the project's operating costs are paid by contract and fare revenues and an average of 1,976 passenger trips are served each month.

Mississippi Band of Choctaws

The Mississippi Choctaw Indian Transit Project serves three counties in east central Mississippi (Figure 1). Although the Choctaws have been providing some transit services for several years it was not until 1981 that the Mississippi Band of Choctaws became a Section 18 Rural Public Transportation Project.

The Choctaws have been in a period of employment transition in recent years with the creation of a moderate industrial park creating more nonagricultural employment opportunities. Much of the Choctaw Transit System emphasis is on meeting work trip demand in the three county area through the provision of the fixed-route, fixed-schedule service between industrial complexes and residential areas. Services are, of course, provided to the general public. Some routes serve the Choctaw High School and services are provided to the transportation disadvantaged.

The Band of Choctaws Tribal Council established a Choctaw Transit Authority to operate and coordinate transportation services. The transit Authority is governed by a Board of Commissioners appointed by the Tribal Chief. The Authority is required to submit an annual report to the Council and Chief describing its operations and financial condition.

Consolidation of transit service responsibility has resulted in expanded service at less cost per unit of service. The project constructed its own maintenance facility and fueling station. Maintenance and repair services are provided for a fee to private as well as public vehicles.

Ninety-seven percent of the project's operating costs are paid by contract and fare revenues and an average of 1900 passenger trips are served each month.

CONCLUSION

In Mississippi, as evidence shows, there is need for unification in the approach to transit for the elderly, handicapped, and other transportation disadvantaged. Being a poor state with few "traditional" public transit systems, the need of the elderly and handicapped will be better met whenever unification becomes reality.

Section 18 Program has given state and local governments a mechanism for enhancing efficiency through broad based flexible transportation operations. Those responsible for providing transportation services should take every advantage of the opportunity to make the best possible use of scarce financial resources in providing transit services to the rural transportation disadvantaged.

Greater local flexibility in the use of funds seems desirable with the state more actively assisting in integrating efforts. Such integrating efforts could include transportation brokerage, determining priorities, assisting in cooperative ventures, pooling financial services, and providing technical assistance in project development. Underlying all these areas of assistance is the desire to give local providers some freedom in their level of initiatives so that, as much as possible, the system remains "theirs".

Vehicle Ownership and Driving Behaviour of Seniors in Canada

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1. Introduction

Very little is understood in Canada regarding the driving activities of seniors, and even less is known about their vehicle ownership patterns. This situation is common in other countries around the world mostly due to a lack of data on the topic. When so little is known, it becomes difficult to plan for any form of transportation services, because authorities are unable to adequately describe the senior population in terms of their transportation needs and requirements.

A recent survey of a sample of Canadians (including seniors) was undertaken in order to be able to mathematically model vehicle ownership and usage for the general population. As a consequence, a rich data set was made available and the activities of seniors could be compared to those of the rest of the non-senior population. Specific data that were available included demographic information, access to transportation, vehicle ownership by type and quantity of vehicle, and a count of vehicle kilometers driven for work and non-work purposes during a one week period.

This article will detail the tabulated findings related to this data set, but no econometric modelling will be reported, largely due to the complex nature of modelling results. For further information on the modelling results using the entire data set, refer to Berkowitz et. al (1984).

2. A Description of the Data Set

The data set was collected as part of a larger project funded by Energy, Mines and Resources Canada in an attempt to be able to predict gasoline consumption on a reliable basis. This has been the subject of a great deal of research, but in Canada no appropriate data were available for the modelling efforts. The data collection procedures were designed by a team at the University of Toronto-York University Joint Program in Transportation, and details of the data collection methods are reported in Wolfe et. al (1984). The following points regarding the data collection are pertinent to this paper:

a) The data were collected on a national basis, excluding the Province of Newfoundland and the Northwest and Yukon Territories. The geographic omissions were due to a lack of data collection support in these regions.

b) The data were collected through a self-administered mail-back survey which included sections on household demographics, vehicle ownership and usage for all vehicles in the household, and vehicle kilometers travelled for each vehicle for every day in a one week period in November 1982.

c) Respondents were selected by a survey consultant and all belonged to a panel of individuals maintained by the consultant. No bias was generated by this sample selection procedure, as no attitudinal data were requested, and great efforts were extended to ensure lack of socio-demographic bias across a number of dimensions. The results were subjected to a detailed comparison to the 1981

Census of Canada and exceptionally positive results were reported in Wolfe et. al (1984).

d) Of the 2400 surveys mailed out, 1997 were returned and 1306 contained all of the required data.

These data are the subject of study in this article, and it must be recognized that the data were collected for a purpose other than that being presented here. As a consequence, the number of seniors analyzed is small, but it is hoped that some information is better than none at all.

3. Demographic Analysis of the Seniors in the Sample

Of all 3009 persons reported in the sample, 448 (or 14.9%) were aged 65 and older. Of the seniors, 41.7% were male and 58.3% female, and 94.6% were heads of household either alone or with a spouse. Figure 1 depicts these data as well as a general age/sex pyramid for the population of respondents.

Figure 2 depicts vehicle ownership by age group and household income category for the entire population. Ownership levels above two vehicles were not included due to the lack of observations of this nature. It is evident that the highest number of zero vehicle households is among the senior population. Also shown is the general lower income levels of seniors (a mean of $14,900 versus $23,200 for the general population). Very few seniors own two vehicles, and few own one vehicle, but most of those who own a vehicle are of low income. Roughly the same number of senior-headed household own vehicles as those who own none.

Figure 3 depicts household tenure type by age of household head. It is clear that the proportion of home owners to home renters does not drop with age of the household head, at least until very advanced age. Figure 4 shows the dwelling types that households live in, again by age of household head. Here it is clear that the proportion of households that live in apartments increases as the age of the household head increases. In fact the proportion is almost 1 to 1 for the most aged household category.

Finally, Figure 5 showns employment status by age of the household head. It appears that about one third of the senior household heads aged 65-84 are employed and most others are retired (or unemployed). Of those employed, about half are professional or white collar workers, and about half are blue collar workers.

From this brief demographic analysis, it is evident that the senior population depicted in this survey is quite typical of North American populations. Some seniors work, most own homes, and only about half own vehicles. In the next two sections, the vehicle ownership and usage behaviour of this population will be examined.

4. Vehicle Ownership Information

It is generally assumed that seniors drive older, inefficient vehicles due to household budgetary constraints. A further problem is that these vehicles are more expensive to maintain and because of their age, break down more frequently. These specific hypotheses were examined in detail and, in general, no evidence was found to firmly support any of them!

Of the 1337 vehicle owned by households in the sample, 210 were owned by households headed by persons aged 65 years and older. Cluster analysis was used to divide the vehicles into eighteen type/vintage categories for purposes of this analysis (and the later modelling efforts not reported in this paper). The category definitions are presented in Table 1 below and were developed with the objective of obtaining several groups which were 'somewhat' homogeneous with respect to fuel consumption and vehicle size.

Table 1: Vehicle Classication Categories

Number	Description
1	Medium Domestic Sedans 1974 and earlier
2	Large Domestic Sedans 1974 and ealier
3	Small Domestic Sedans 1975-79
4	Medium Domestic Sedans 1975-79
5	Large Domestic Sedans 1975-79
6	Small Domestic Sedans 1980 and newer
7	Medium Domestic Sedans 1980 and newer
8	Large Domestic Sedans 1980 and newer
9	Medium Domestic Wagons
10	Large Domestic Wagons
11	Foreign Wagons
12	Volvos
13	Very Small Foreign
14	Small Foreign
15	Medium Trucks
16	Larger Trucks
17	Sports Cars
18	Luxury Cars

In Figure 6, it can be seen that the percent of older, large cars is only slightly higher for seniors than for the non-senior population. Seniors do own substantially fewer foreign made vehicles, fewer trucks and no sports cars. Otherwise, popular categories are medium sized, newer vintage vehicles. In Figure 7 it further apparent that seniors hold only a slightly larger proportion of high fuel consuming vehicles. They do own a smaller proportion of highly efficient cars, but this could be accounted by the lower percentage of foreign cars owned by seniors. Detailed examination of the data therefore shows that vehicles held by seniors are similarly distributed for the non-senior population.

This was an unexpected result and could not be immediately explained. One possible reason is due to the harshness of Canadian winters. Older, unreliable cars do not do well in this weather, and it might be possible that seniors opt to spend their vehicle budget on purchasing more reliable cars rather than maintaining older ones. In addition, do to the widespread use of road salt, vehicles don't last that long anyway, and rust rapidly.

Regardless, it appears that seniors who own vehicles spend a large portion of their income on their vehicles, probably a larger proportion than the non-senior population. Unfortunately data were not available to substantiate this hypothesis, but Figure 2 does show that seniors that own vehicles have lower incomes than the rest of the population. If they spend part of that income on similar auto purchases, than they may be spending a larger proportion of their income on this item.

5. **Vehicle Use Behaviour**

One might expect that seniors drive less than the rest of the population, as few seniors commute to work, and seniors do not have the travel requirements of pre-driving age children imposed on them. This was found to be the case, but not by a large extent. It can be seen in Figure 8 that the relative proportion of people driving between 1 and 200 and 3 and 400 kilometers per week is lower for senior headed households. Curiously, though, there is evidence of several high mileage households among the senior group.

Further analysis was conducted to determine if the availability of transit within 1/4 mile (that is walking distance) had any effect on kilometers travelled. The results shown in Figure 9 are very unusual in that they show that households travel more where transit is available. It appears that a much higher percentage of seniors have low vehicle usage per week, but more so for areas with transit than without transit access. This may be explained by the fact that good transit access is only provided in large cities and because travel distances for many purposes are greater in larger than in smaller cities. This hypothesis could be proven with data not shown here.

Therefore, in general, it was found that seniors do travel slightly less than the non-senior population, but not by a large amount.

6. Conclusions and Summary

In this brief analysis, it has been shown that the driving behaviour of the Canadian senior population is not very different from the non-senior population. Differences are small, and it can be concluded that seniors who own vehicles may spend a great deal to keep them but use them actively and are quite mobile. This further accentuates the often-stated point that seniors who do not have access to a car or transit are highly deprived of their mobility and have significant travel requirements that are not met by any means. Quite clearly the vehicle owning senior household is not a member of this deprived group.

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FIGURE 1
Age/Sex Pyramid

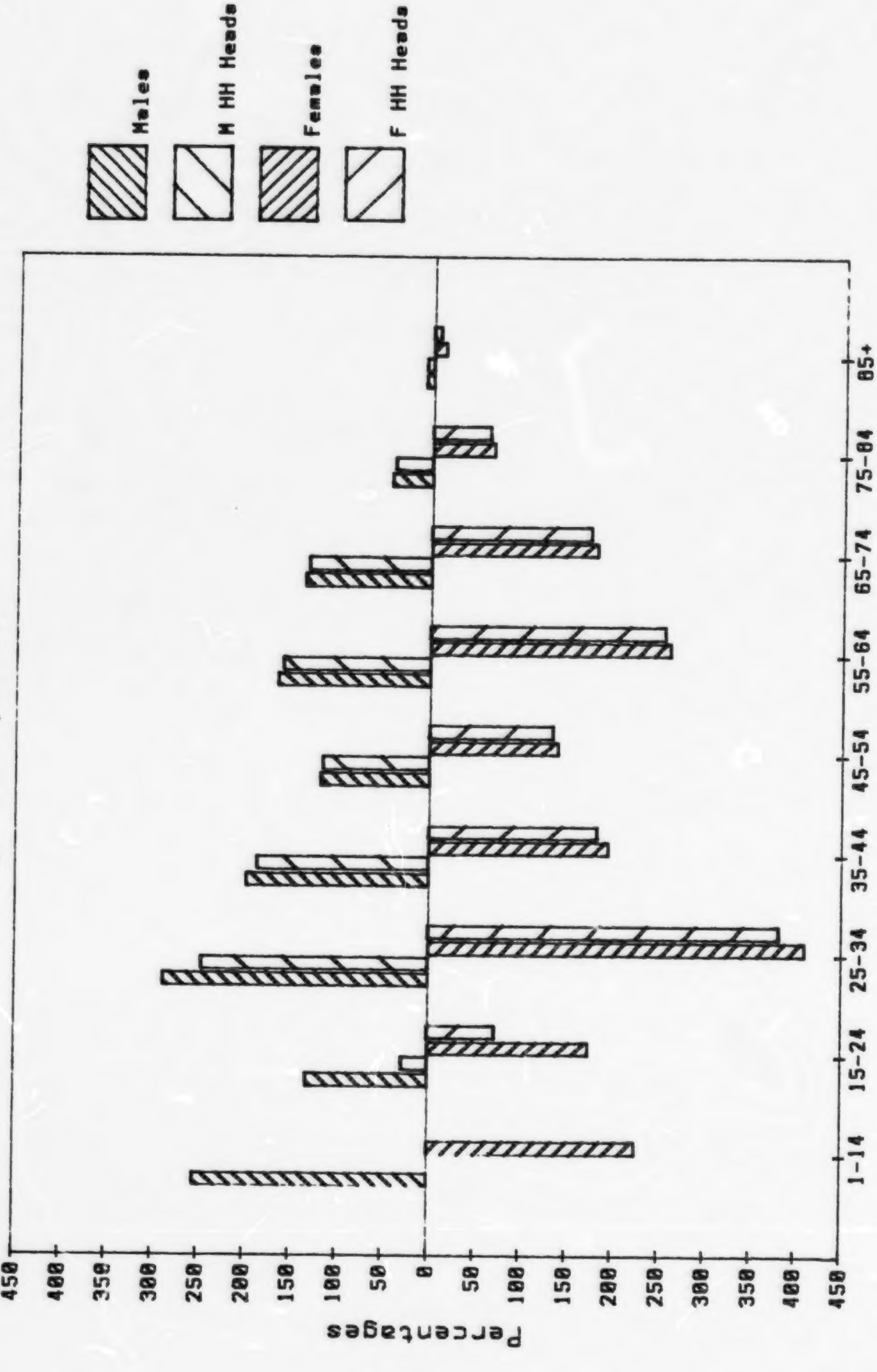
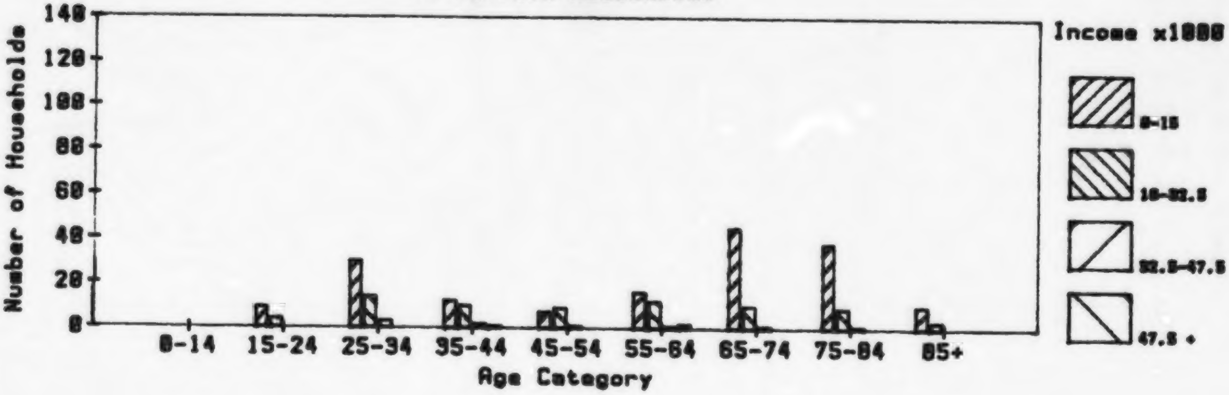
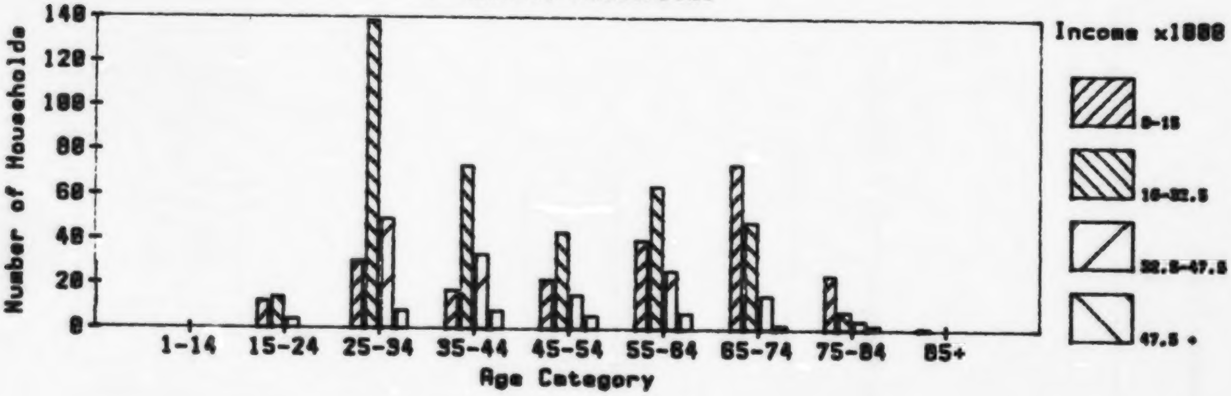


FIGURE 2
Vehicles by Age and Income
0 Vehicle Households



1 Vehicle Households



2 Vehicle Households

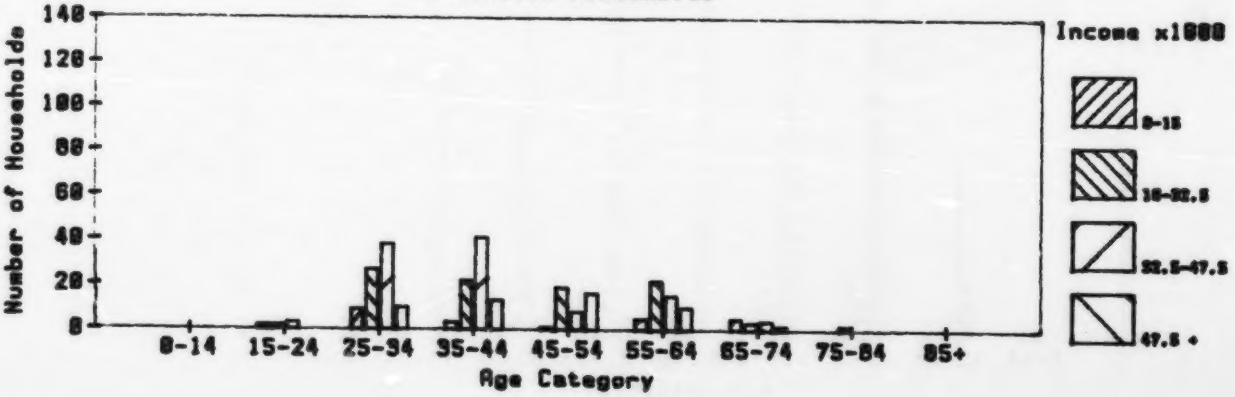


FIGURE 3
Tenure by Age of Head

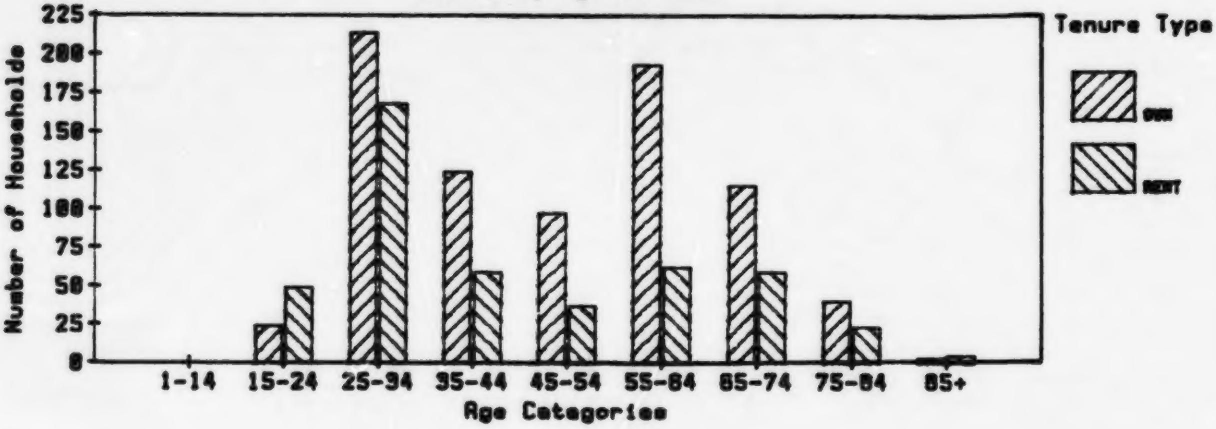


FIGURE 4
Dwelling Types by Age of Head

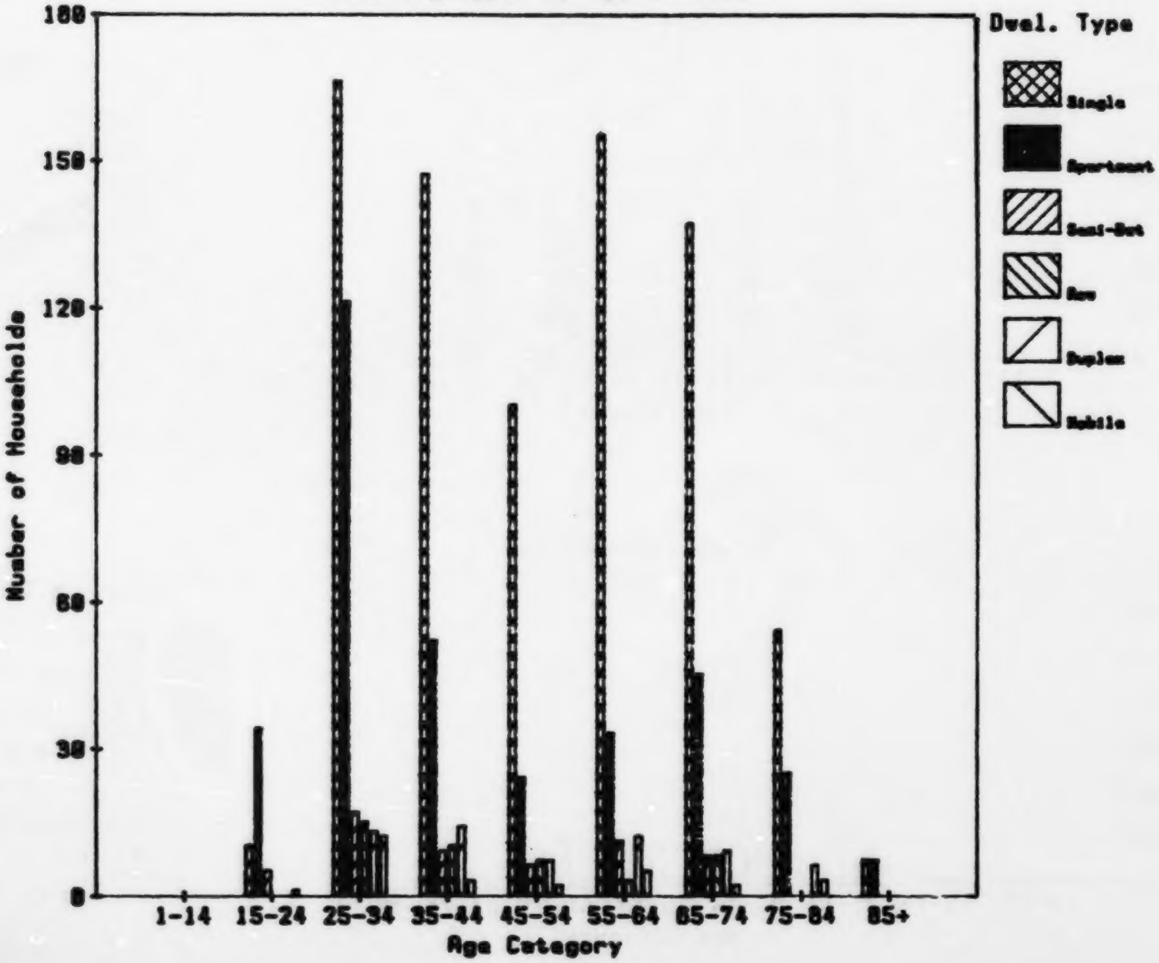


FIGURE 5
Employment Status by Age of Head

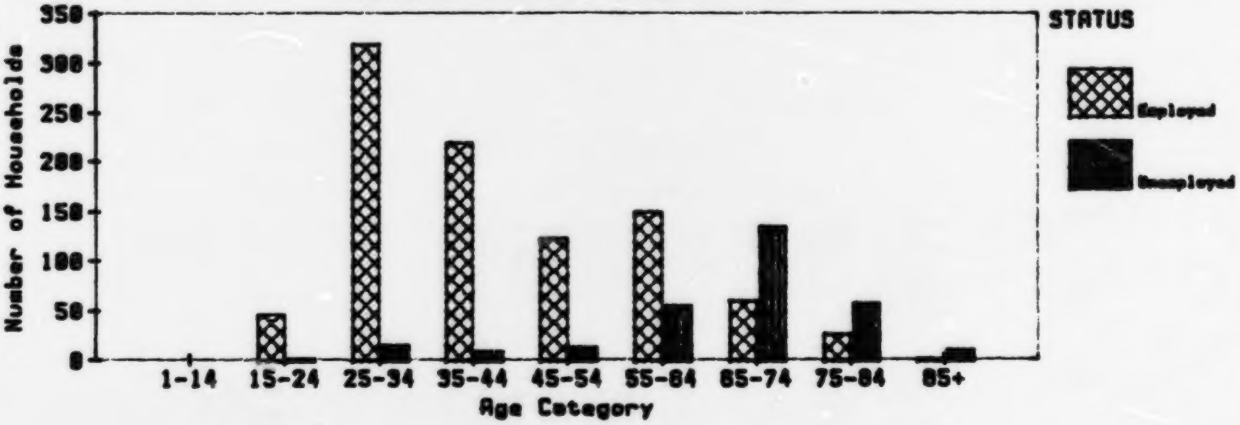


FIGURE 6
Vehicle Type Categories

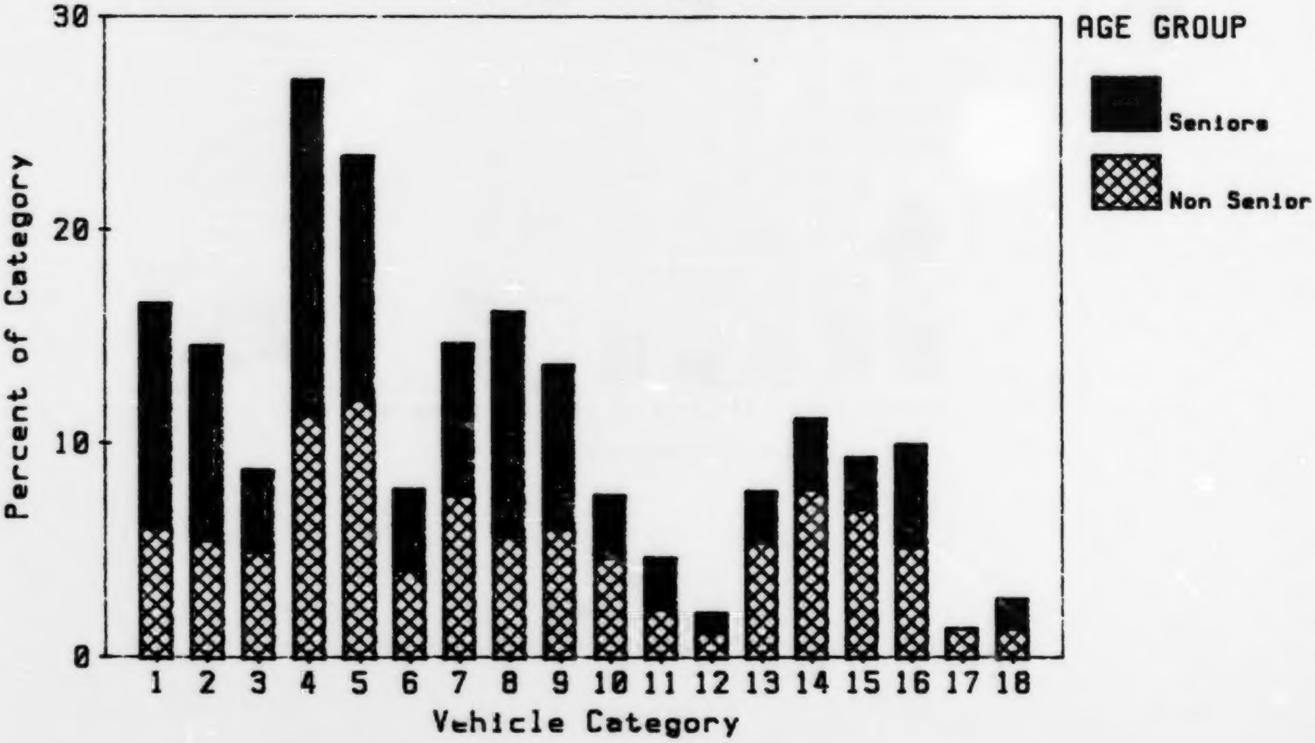


FIGURE 7
Age of Head vs MPG

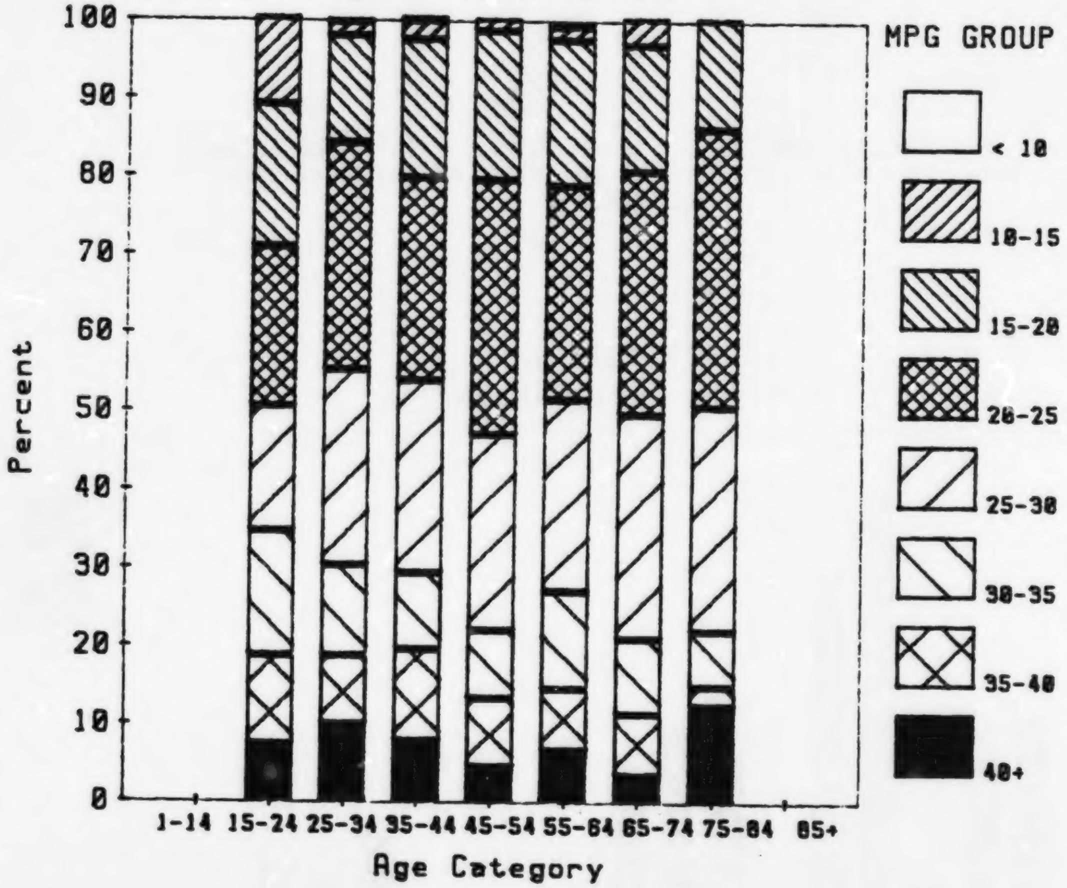


FIGURE 8
Vehicle Kilometers Travelled

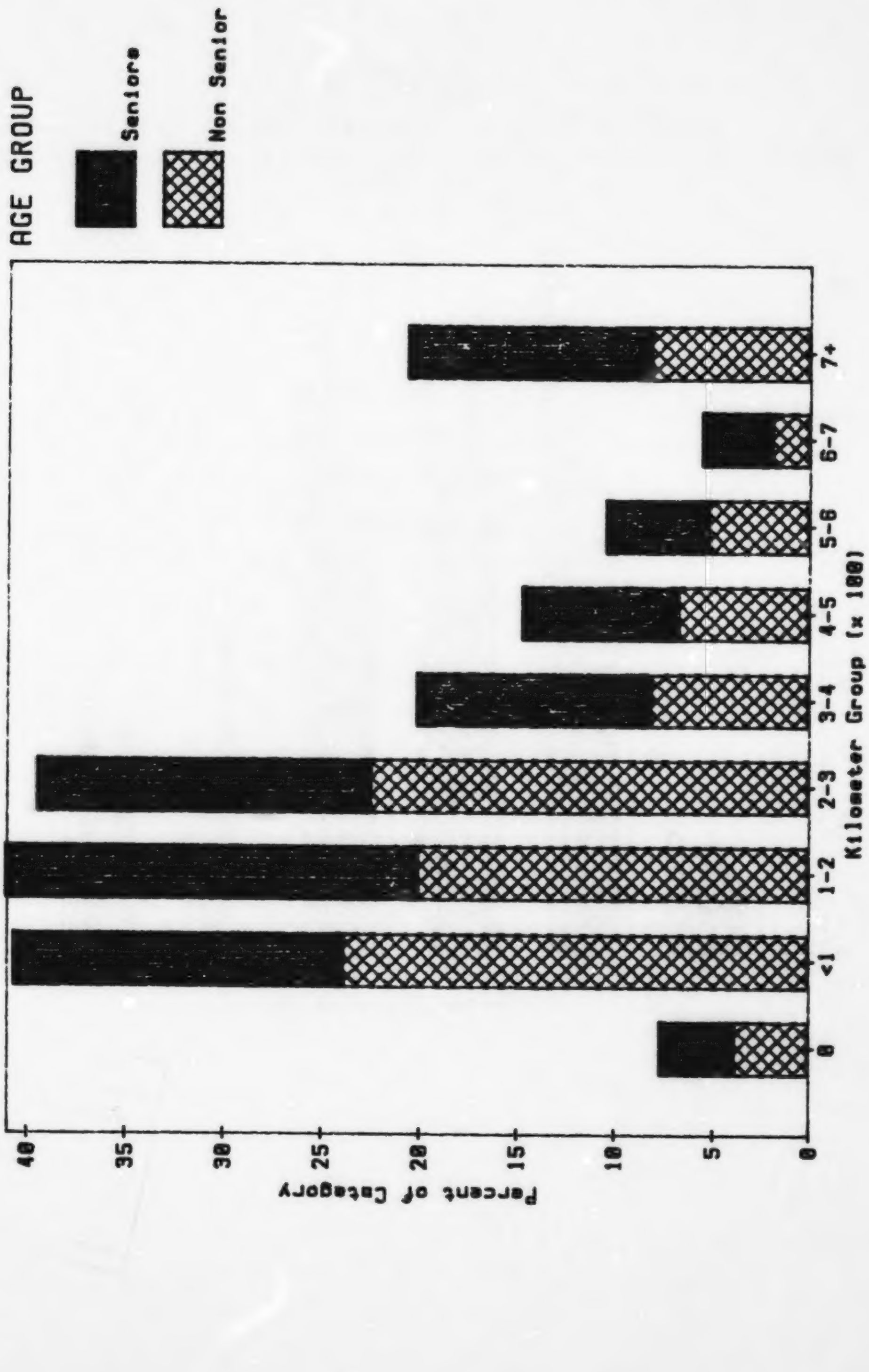
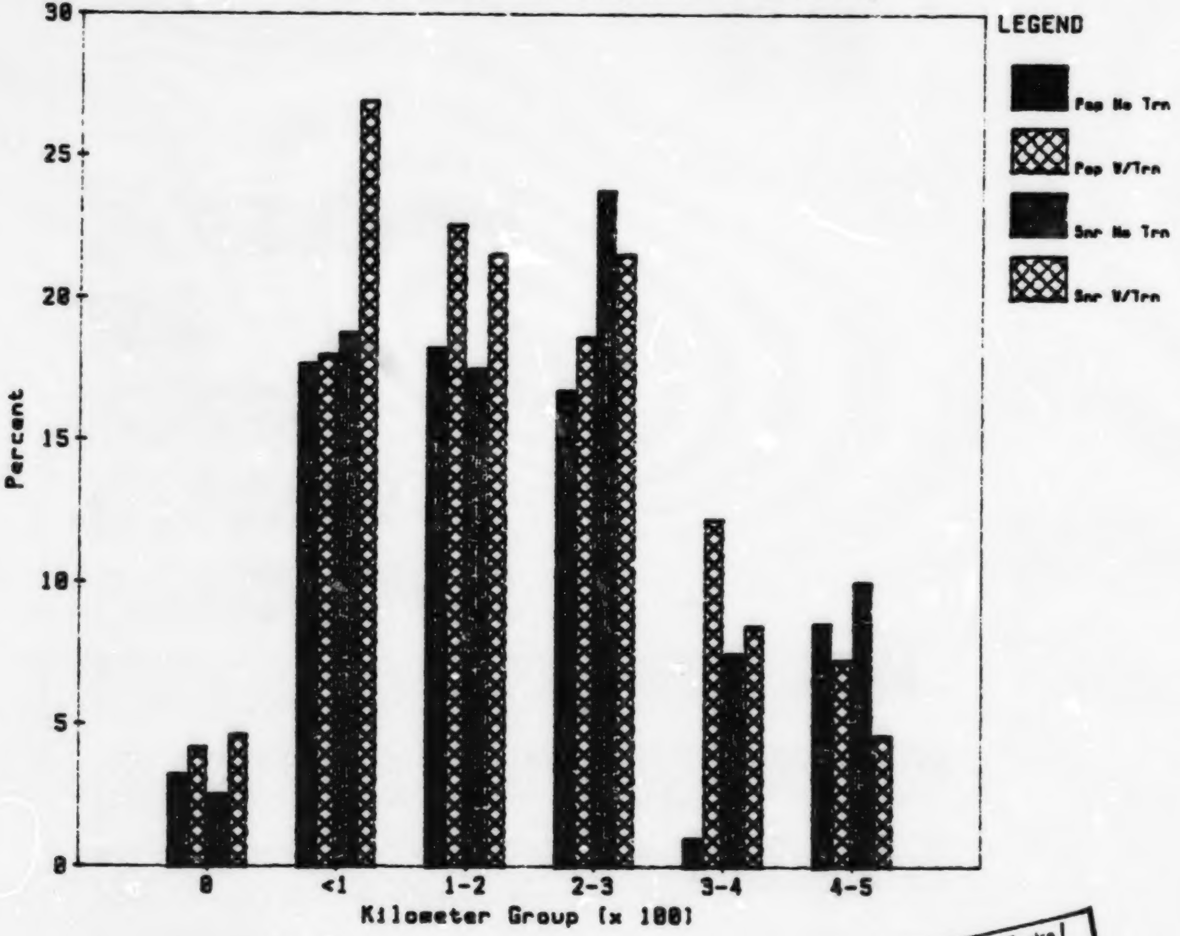


FIGURE 9

Vehicle Km. and Transit Availability



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